1968

NEW DEVELOPMENTS IN JOINT SEALING PRACTICE

FOR LONGER SPANS

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- -

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(Confidential and not for Publication)

INTRODUCTION

With respect to the design and construction of bridges, the ratio of technological advance in the past ten years has probably been equivalent to, if not greater than, that of the last 50 years.

Refinements in structural analysis; improved knowledge of material properties; wider use of prestressed concrete, composite construction, all-welded structures and battle decks; as well as radical changes in aesthetic tastes resulting in more slender lines have operated to place increased emphasis on the need for improvements in jointing and joint sealing practices for our modern bridges and structures.

Structural failure of bridges could have such serious consequences that no chances should ever be taken and yet recent international condition surveys both here and abroad give evidence that bridge deterioration at the joints, or in the vicinity of the joints, together with premature distress causally related to ineffective joint sealing practices is an ever increasing problem of heroic proportions. Voluminous documentation has been presented in the last decade which supports the future design thinking that joints on bridges should be eliminated or at least numerically minimized wherever possible. It must also be categorically stated that every effort should be made to seal the remaining few existing joints on bridges and structures.

It is the intent of this discussion to re-define the magnitude of this developing problem, to survey what has been accomplished both here and abroad and to suggest what can be done in the light of present knowledge.

A GROWING NEED FOR IMPROVEMENTS IN JOINTING PRACTICE ON BRIDGES

The recent trend in bridge building has been away from conservative designs with relatively low live load to dead load ratios.

Graceful, aesthetically attractive, thinly contoured structural shapes are appearing on the scene not only because of their obvious attendant economies, but because of a strong competitive

effort to excel on the part of design engineers throughout the world. The practice in some countries of having engineer-contractor firms submit competitive bridge designs toward an end results specification has resulted in a multiplicity of daring design configurations which not only stimulate ones imagination, but are in reality a prediction of the future. (See Figures 1 - 14).

The obvious need for improvements in damping is indicated when a loss in stiffness has been granted. As cross sections are thinned out, bridge responses to the forces of excitation must be dealt with and since this is logically in the province of the jointing system, it is being readily accomplished utilizing the principle of compression.

A tendency toward the increasing use of segmental cantilever construction resulting in long spans jointed midway between bents produces live load vertical deflection considerations at these joints which can require sophisticated doweling or load transfer mechanisms that in order to effectively perform for the life of these structures, must be kept free of deleterious chemicals and foreign intrusions. (See Figures 13 & 14).

Many designers feel that their bridges are things of beauty and public pressure to improve their appearance is leading to the increasing usage of bright, eye catching colors. Canadian bridge engineers have recently used almost every color in the rainbow on their structures not only to emphasize their graceful contours, but more important, to attract and favorably impress visitors with the merits of this potential growth area. (See Figures 15 & 16). Unfortunately, the tiniest leak through a joint on a painted structure can quickly stain and detract from its original beauty.

The latest post tensioning systems permit daring new designs that are accompanied with sliding, rotating, needlelike bearings which permit a structure to fully respond in a wide variety of horizontal, vertical and articulating motion patterns that must be accounted for in a jointing system. (See Figures 17 & 18).

Salt brine corrosion and resultant section loss to bridge members, sub decks and piers, underneath, and in the area of the joints, can no longer be tolerated. The highly desirable rapid trend toward prestressed concrete and post tensioning systems does not take into account, nor can it tolerate a potential section loss from the effects of corrosion-erosion.

The migration of backslopes away from backwalls due to

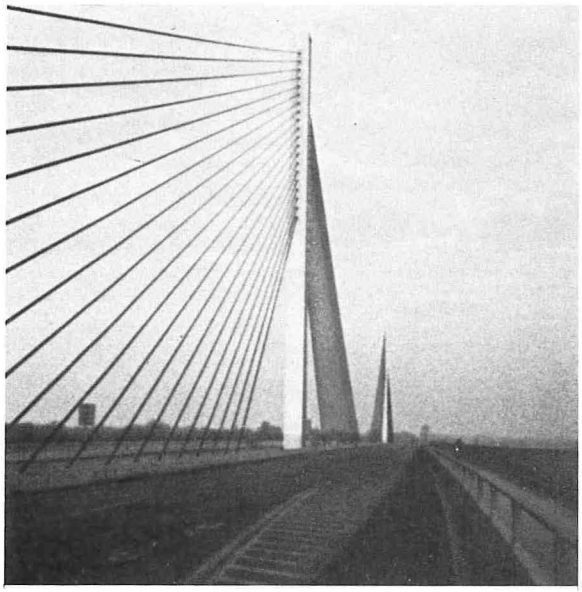

Figure 1 "Rhine Harp" Bridge 1706 ft. continuous span supported by 161 ft. twin pylons with steel hawsers.

Figure 2 Curved prestressed box girders with 1256 ft. main span and minimal supports due to currents & ice at Florenceville, New Brunswick.

Figure 3 Pylon & cable stays support thin steel bridge over German Autobahn near Koln.

Figure 4 Thin continuous span prestressed concrete structure on British M4 Motorway near London Airport.

Figure 5 Thin fixed arch open spandrel at Opporto in Portugal.

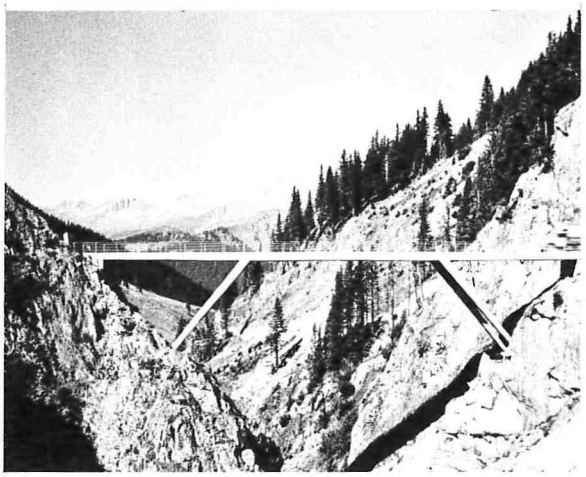

Figure 6 Needle thin Swiss-German design.

Figure 7 307 ft. long pedestrian arch bridge over Rhine River near Weisbaden with 145 ft. end sections in lightweight concrete; center portion of standard weight concrete.

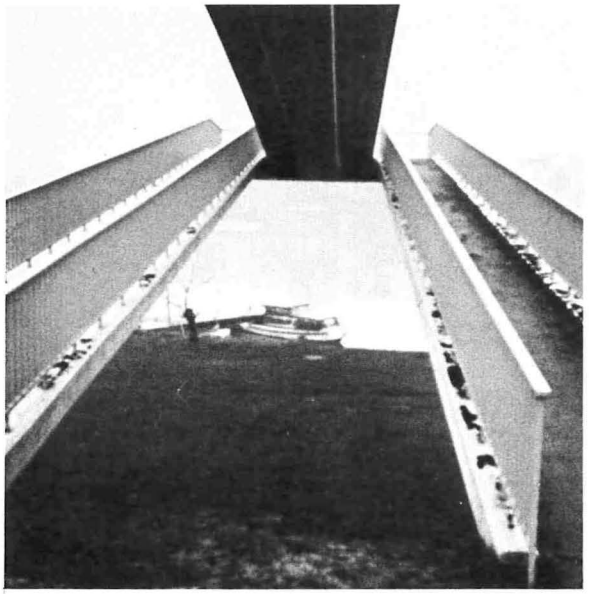

Figure 8 87 ft. long cantilevers form ends of Weisbaden Harbor pedestrian bridge built with white cement.

Figure 9 Distinctive concrete tower support with concrete stays on Travata Nell Ansa Viaduct shows influence of Italy's Prof. Giuseppe Morandi.

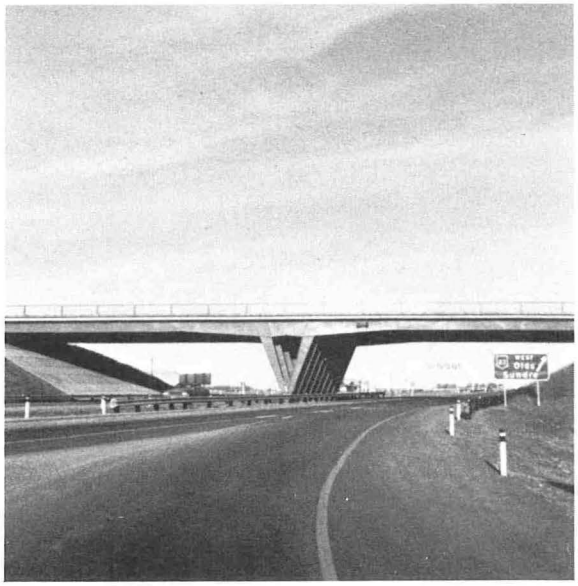

Figure 10 Lightweight steel structure free of side supports forms overpass near Hobbema, Alberta.

Figure 11 Very thin post tensioned bent supports a curved structure over Italian Autostrada.

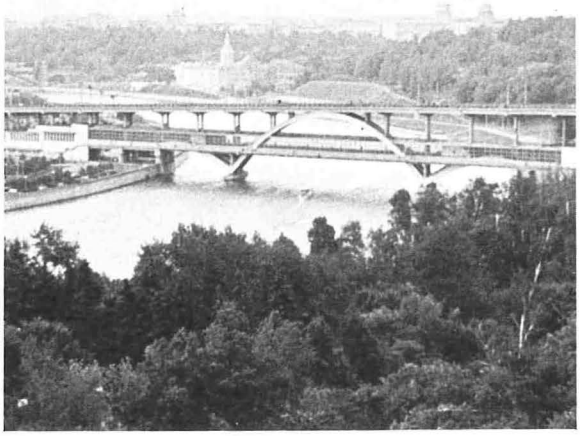

Figure 12 Russian lightweight fixed arch-open spandrel, dual level bridge over Moscow River.

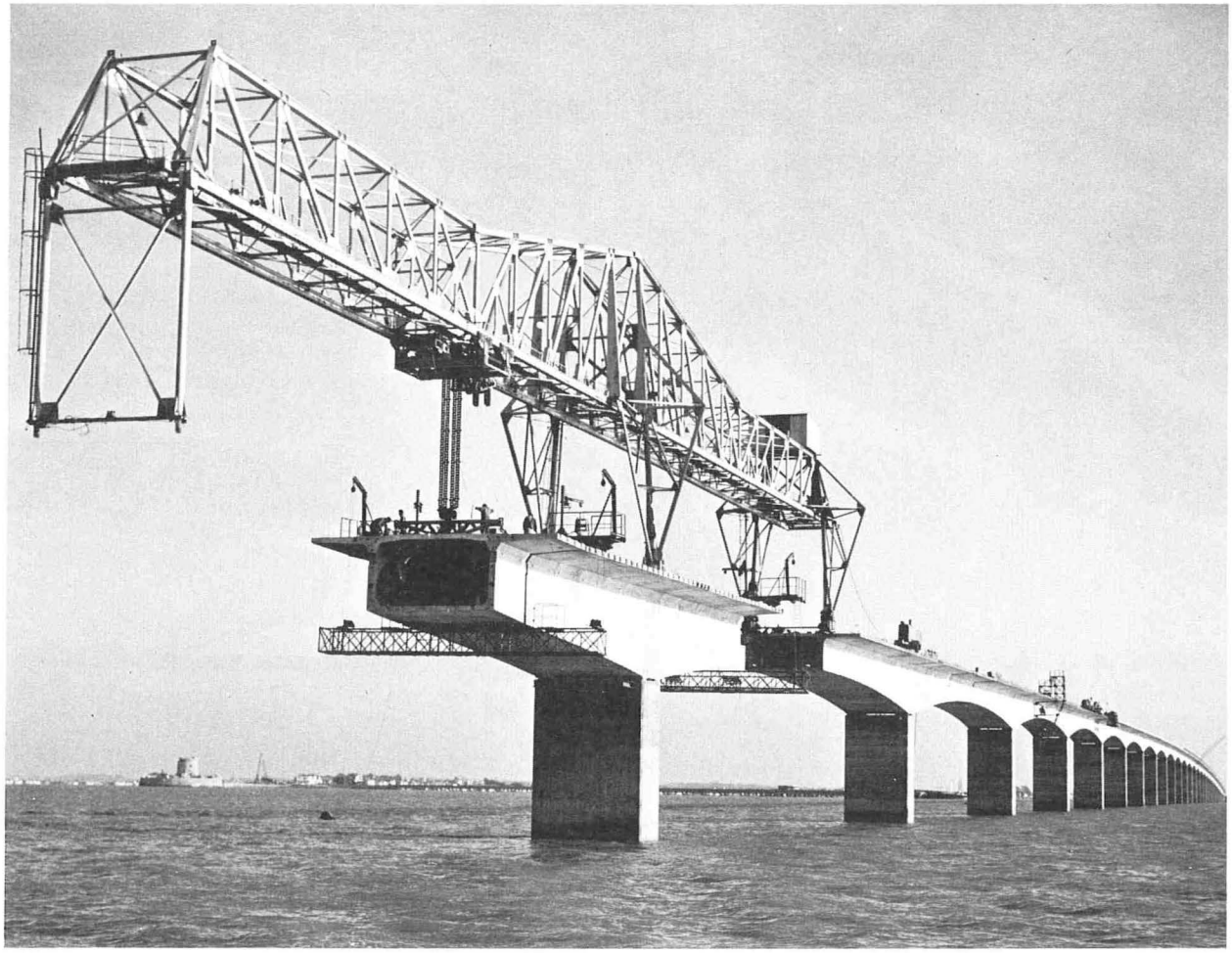

Figure 13 Viaduc Ile D'Oleron off West Coast of France. Segmental cantilever construction. $\pm$ 60mm movement at joints.

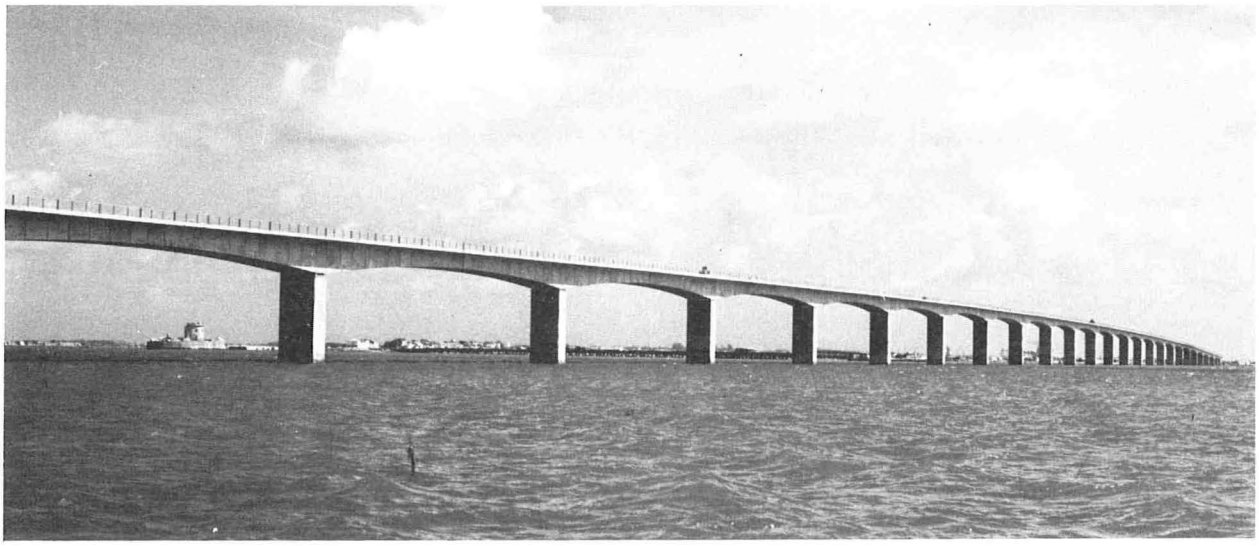

Figure 14 Viaduc Ile D'Oleron. 2863m total length. 79m balanced cantilever spans. Span ends are stepped resting on neoprene pads.

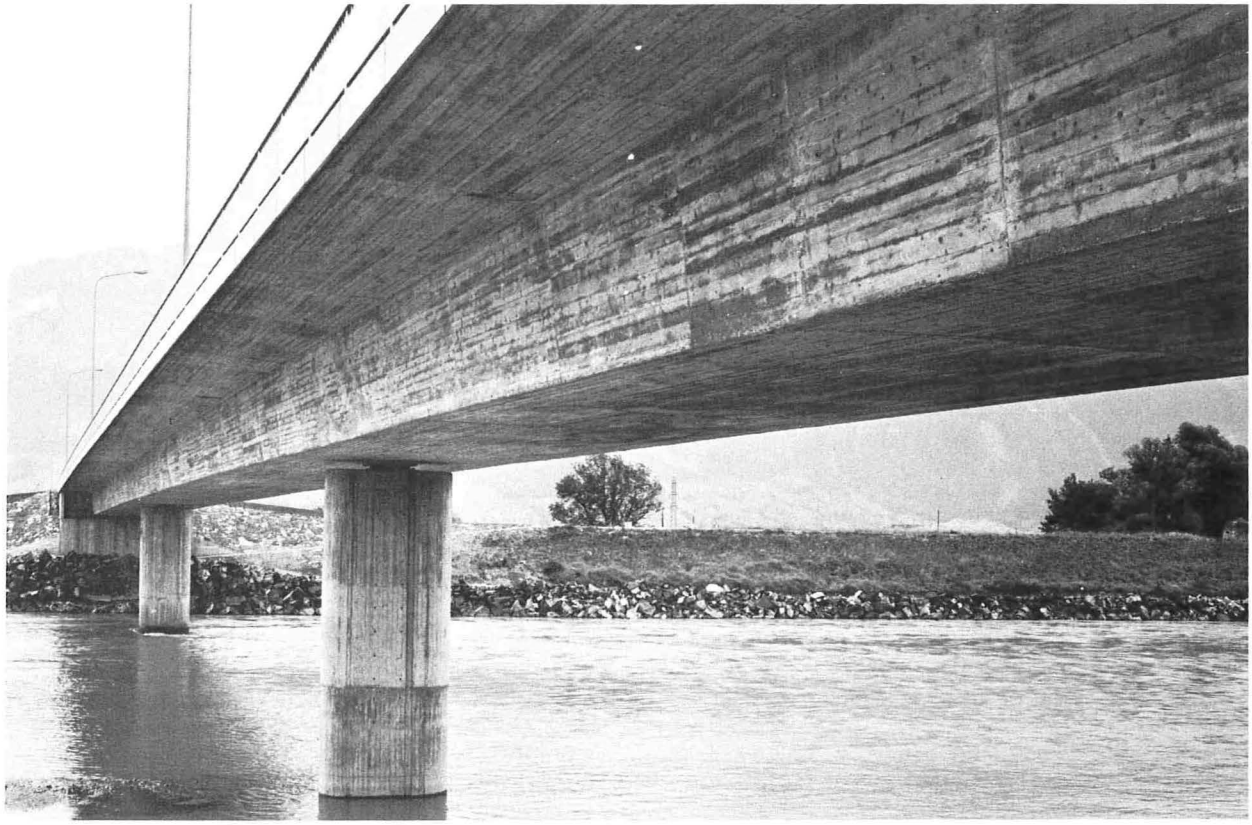

Figure 17 Haag-Bendern Bridge connects Switzerland & Liechtenstein. 4" movement at joint, articulating bearings.

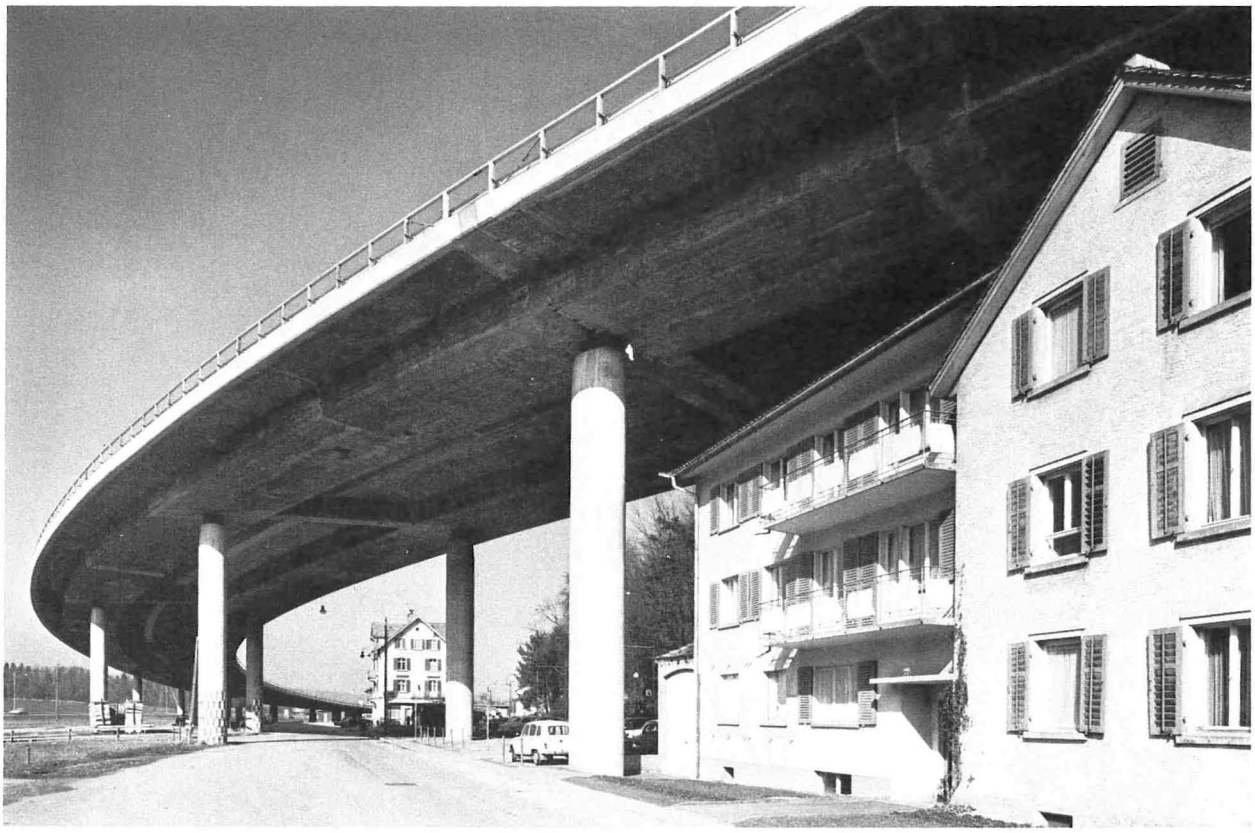

Figure 18 Curved prestressed bridge at Zurich, Switzerland with 1250 ton bearing for $\pm$ 4,5cm movement.

the rapid flushing of water through joints leaves a bridge vulnerable to both pavement thrust and earth pressures and must be ended once and for all.

The fact that every bridge has a potential for premature self-destruction by means of the entry of salts, chemicals, solids, and water through the joints has been thoroughly documented and needs no further elaboration in this report.

A PERFORMANCE CHECKLIST FOR A LONG SPAN SEALING SYSTEM

In general, a candidate sealing system for a long span bridge should be checked for equivalency with respect to the following performance needs on bridges:

1. It must have the capability to successfully respond to the many different types of movement that might occur on a specific bridge, whether it be straight distance change between the joint interfaces, racking distortion from the many variations of skews, horizontal, angular, vertical and articulating motion patterns, eccentrics of curved girders, differential vibrations of slab ends, impact, warping and rotation effects, permanent changes in deck length, creep, plastic flow, etc.

2. It must have the capability to respond to the individual magnitudes of the above categories of movements both singularly and when acting in concert.

3. It must seal out the entry of incompressibles, compressibles and in fact, all types of foreign material with a restraint producing potential and guarantee that bearing seats, shelves, pier caps, bents, do not receive accumulations of these materials together with chemicals deleterious to steel and concrete's performance life.

4. It must seal out the entry of free water in a leak proof manner and assist in channelizing the water into the drainage system of the structure.

5. It must be capable of absorbing the various types and ranges of movement within itself without being extruded above or expelled from the joint opening.

6. With respect to the riding surface of the sealing system, it must be constructed of materials which have a capability to withstand wear and impact such as is produced from forces of repetitive and heavy traffic loadings coupled with ice, snow, slush, maintenance materials and incompressibles, the forces of abrasion from snow plow blades at low temperatures, abrasive effects of sand, silt, small stones, gravel, grit, laitance, etc.

7. It must be capable of performance in extremes of temperatures for the environment of each particular structure. (Bridges in Alaska encounter minus 70 degrees F while bridges in Southwestern United States can build up deck temperatures of plus 150 degrees F.

8. The sealing system must be constructed of materials that have a long outdoor service capability. All materials utilized must be relatively unaffected by sunlight, ozone, petroleum products, chlorides, deleterious chemicals from industrial smog, maintenance chemicals, cement alkalis, as well as tensile and compressive stress of long term duration.

9. The surface of the sealing system should have provision for skid resistance if the device is of a longitudinal width greater than 8 inches.

10. The sealing system should be easily capable of inspection and maintenance and have provision for adjustments to take into account one-time or permanent changes in the bridge deck length (positive or negative creep) as well as movements from pavement pressures, settling of abutments or other similar forces commonly brought to bear against decks and abutments.

11. The sealing system should allow relatively unrestricted movement of the bridge to relieve stresses due to temperature, creep, shrinkage and loading unless the bridge is designed to accept these categories of stress. Should a device produce excessive stress, it could be capable of ejecting a bridge from its bearing points or produce other undesirable forms of stress relief.

12. It should have a service life at least equal to the life of the deck surfacing and ideally to the life of the bridge. Short lived sealing solutions should have provision for simple and easy replacement with minimal cost.

13. The sealing system should have good riding qualities and generate neither noise nor vibration due to traffic.

14. Wherein the joint opening exceeds 4 inches at the widest point of opening, the sealing system should provide adequate structural support for traffic loadings that are not subject to rapid attrition or wear.

15. The sealing system must be equally effective at the juncture of the pavement and curb, this being the critical area for sealing of the bridge.

16. Leakproofing being a necessity, the sealing system should be free of breaks or field joints within the line of a given joint. Where sections of elastomeric tubes are fabricated in pieces shorter than the actual length required, they should be factory vulcanized.

17. The sealing system should assist in providing the structural damping requirements of the bridge.

SAWED EXPANSION JOINTS ON BRIDGES

A compression seal or any high type sealing system can potentially only remain effective as long as the joint interfaces maintain their structural integrity. (See Figure 19).

Preformed compression seals are in reality elastomeric parts extruded to geometric precision that, ideally, must fit into a predetermined, pre-engineered precise shape or receptacle. Since two different firms produce these two shapes under widely differing conditions with different materials, it is not surprising that variations can produce problems.

Due to the complete absence of precision control of the desired joint geometry plus a marked tendency toward durability loss from the old hand edging process, a recent trend is now in evidence throughout North America toward the sawing of expansion joints, not only in concrete pavements but in bridges as well. Ideal control of expansion joint geometry including the forming of relief seats or steps is now being achieved by tandem blade or multiple blade sawing. Figure 20 illustrates the mechanics involved. Sixty horsepower saws with thick steel cores on the diamond blades appear to be a requisite to provide the necessary power for two or more blades while the blade

Figure 15 Bridge near Montreal with color dynamics in red trim over buff colored concrete.

Figure 16 Pink bridge railing on white concrete adds aesthetics to a bridge in Quebec.

Figure 19 Post installation spalling related to poor construction practice.

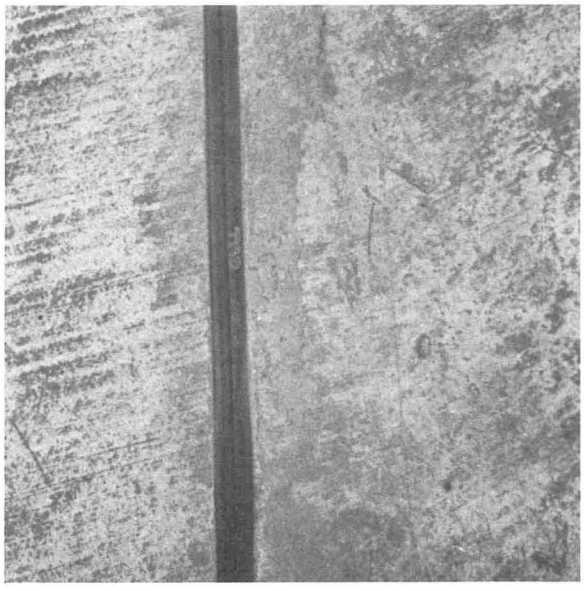

Figure 21 Excellent ridability and pleasing aesthetics of a sawn bridge joint.

thickness is desirable to prevent warping or twisting when hard aggregates are encountered. A number of blades may be joined together similar in principle to a diamond bumpcutter or more simply, spacers between two blades can accomplish a similar result. 24" diamond blades which are readily available from industry are popular in this application because of their sawing depth versatility since depth to width ratios increase or decrease to reflect the variable performance needs of individual joints. These large blades also can be used to saw up and through curb contours as well. A final conditioning is to rub or grind a 1/4" or 1/2" radius as desired to the top edges by means of abrasive bricks or tools resulting not only in a joint edge of maximum durability but one of pleasing aesthetics. (See Figure 21).

Figure 22 illustrates a typical working specification for sawing bridge expansion joints in one state highway department with a conversion table for relating temperature to width.

IMPROVED ADHESIVES WITH "RUBBER TEARING" BONDS

The great need for leakproofing and the relatively high percentage of unpredictability of movement at bridge joints has over the years indicated a need not only for a high-solids lubricant adhesive, but a bonding agent that can actually stretch a compression seal which for some unforeseen reason has been called on to perform beyond its original uncompressed width. Typical racking movements of the many variations of skews results in a skew creep action that suggests the desirability of high type bonds.

The original concept of a compression seal was based on the principle of a compartmented elastomeric vulcanizate always kept in compression. While some of the original installations were accomplished using an oil soap, experience has shown however that regardless of how much pressure may be generated in compression against joint interfaces; the presence of dry shrinkage cracks, porosity, cavitation, microcracking, mill scale, etc., can result in the passage of salt brine through even the tightest of sealed joints.

The mission of the lubricant-adhesive then is threefold; to lubricate the interfaces and permit ease of installation, to prime the joint interfaces with a high solids filler, and to produce a rubber tearing bond. It is considered essential that an impervious continuity between the extrusion and the end of the deck be achieved.

Recent laboratory tests and confirming field installations have now proven the feasibility of accomplishing the above on bridge joints by means of high type adhesives. There are limits and laboratory tests have shown that when conventional seals have been stretched some 25% beyond their uncompressed width, the bonds begin to fail in peel from tangential stress as the configurations begin to severely distort. (See Figure 23).

The additional versatility of movement now available through conventional bridge seal configurations by means of these new adhesives now adds 25% to the existing 15% compression safety factors or an overall potential improvement of 40% in performance if needed, a most desirable achievement.

Shifting piers, creep, unusual shrinkage, temperature-width construction complications, progressively opening joints, differential bearing friction, gravity forces in inclined plans, braking loads, or a multiplicity of reasons for erratic and unpredictable interfacial movements can now be handled more effectively with this increase in effectiveness of existing typical seal configurations.

Because such minute quantities of lubricant-adhesive are involved, the very finest of adhesives can be used since the increase in cost would be negligible.

One new adhesive has now been field tested that gives the additional advantage of being workable in the presence of free water, having originally been used in underocean cement concrete bonding applications, repairing underwater pier scour, etc. It is a problem in the field on perfectly warm, sunny days to have joint interfaces in a state of perspiration or to work in inclement weather and the advent of these new aqueous adhesives appears to present a welcome solution to this complication for most adhesive formulations.

SKEWED JOINTS ON BRIDGES

Since a very high percentage of bridge joints are constructed on some varying angle of skew, special consideration should be given to determining the magnitude of racking movement that occurs when these longitudinal and angular movements take place at the interfaces of joints concurrently.

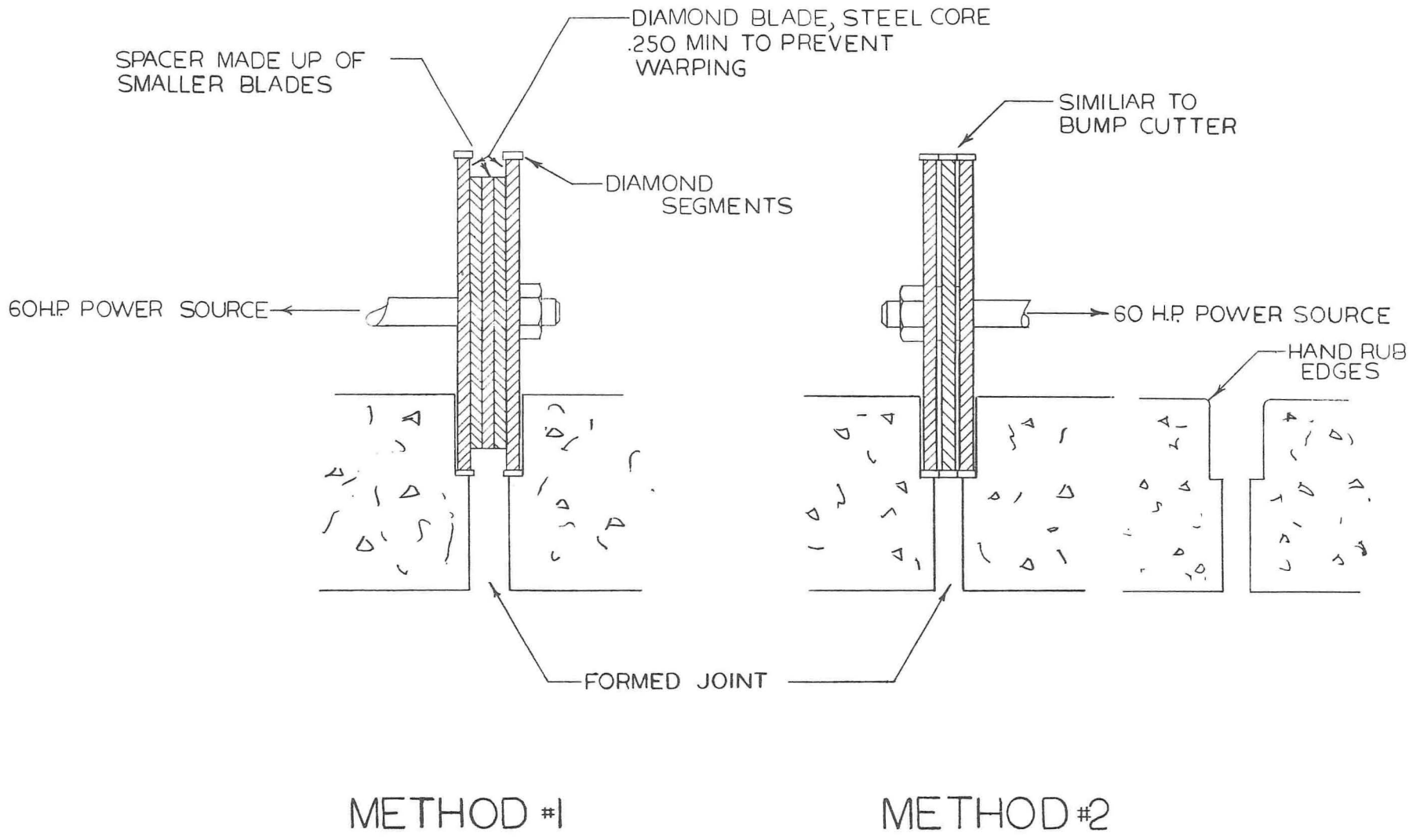

Figure 20 Alternate methods for sawing of bridge expansion joints.

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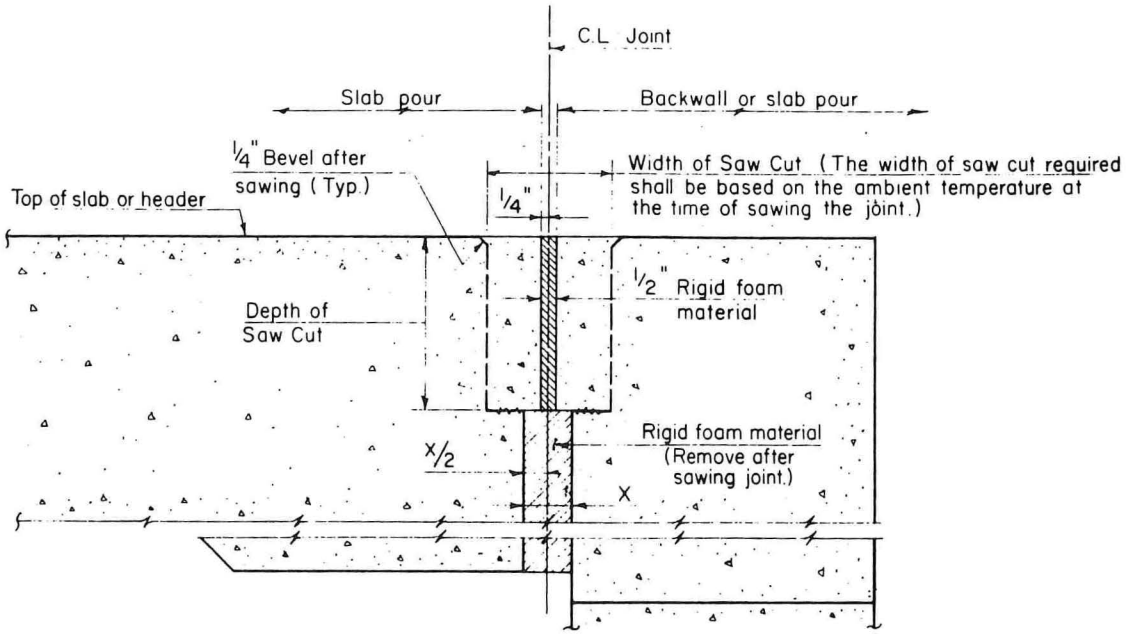
C.L Joint
Slab pour
Backwall or slab pour
1/4" Bevel after sawing (Typ.)
Top of slab or header
1/4"
Width of Saw Cut (The width of saw cut required shall be based on the ambient temperature at the time of sawing the joint.)
1/2" Rigid foam material
Depth of Saw Cut
Rigid foam material (Remove after sawing joint.)
X/2
X

JOINT DETAIL FOR
ELASTOMERIC COMPRESSION SEAL

TYPE JOINT	L	Elastomeric Compression Seal NOM. WIDTH	Elastomeric Compression Seal TYPE	Joint Dimensions: Width of Saw Cut — Ambient Temperature Range at Time of Sawing Joint 30°-50°	50°-70°	70°-90°	Depth of Saw Cut — Elastomeric Compression Seal Type "A"	"B"	"C"	X
Fixed	———	2"	"A" or "B"	1 1/4"	1 1/4"	1 1/4"	2 3/4"	2 3/4"	———	1/2"
Exp.	Up to 55'	2"	"A" or "B"	1 3/8"	1 5/16"	1 1/4"	2 3/4"	2 3/4"	———	1/2"
Exp.	55' to 90'	3"	"A" or "C"	2 1/16"	1 15/16"	1 13/16"	4 1/8"	———	3 7/8"	1"
Exp	90' to 125'	4"	"A" or "C"	2 3/4"	2 9/16"	2 3/8"	5 3/4"	———	5"	1 1/2"
				30°-40°	40°-50°	50°-60°	60°-70°	70°-80°	80°-90°	
* Exp.	125' to 135'	4"	"A" or "C"	2 13/16"	2 11/16"	2 5/8"	2 1/2"	2 7/16"	2 5/16"	1 1/2"

*(d) Depth of Saw Cut same as above for 4" seal

TABLE A

PLAN NOTES:

NOTE WELL: It is important that the joint be constructed exactly as detailed

See TABLE A for joint dimensions.

Saw cutting will be permitted seven days after the final pour at the joint

The compression seal shall not be installed above temperatures at which the width of joint is less than 60% of the nominal width of the seal.

Cost of rigid foam material to be included in the contract item for Class "F" Concrete.

DESIGN INFORMATION:

L = Maximum length of superstructure contributing to expansion.

Plans shall indicate the size and location of compression seals and pertinent information from TABLE A

Use this PLATE in conjunction with PLATES: 4-4.6 and 4-4.7.

(d) Denotes design information

JOINT DETAILS FOR ELASTOMERIC COMPRESSION SEAL	CONN. STATE HIGHWAY DEPT. BRIDGE DESIGN SECTION
REVISED:	PLATE: 4-4.5

Figure 22 Typical work specification for sawing bridge expansion joints illustrating temperature to width controls.

There are definite limitations in the amount of racking movement that typical sealing systems can handle under certain conditions. The point within the stroke of movement at which a sealing system is activated or installed can very well make the difference between a success or failure. Actual tests should be made to determine how much racking stress a sealing medium can absorb for a given slab length and a specific angle of skew. Figure 24 shows a typical testing machine which facilitates the programming of any angle of skew together with longitudinal movement up to 3 inches.

When a sealing system's ability to absorb racking is exceeded, consideration should be given to bonding or fixing one side of the sealing element while arranging for the opposite side to be free sliding, possibly utilizing a surface of fluorocarbon (Teflon).

RUBBER CUSHION JOINTS

Since World War II, as European countries began to rebuild their highway and bridge systems, a wide variety of designs of rubber cushion joints have been experimented with on bridges.

Basically, they consist of thick (usually 50mm), elastomeric pads which are affixed, glued or bolted to the deck at the slab ends over a moving joint opening, performing in stress reversing cycles of tension and compression. Since these thick rubber pads of relatively high durometer (70 Shore A) would undoubtedly require a force greater than the tensile strength of concrete to be stretched to their design limits, relief holes, slots or striates are incorporated to permit the rubber cushion to flex more readily in response to the thermal volume changes of the bridge. Some examples of rubber cushion joints are shown in Figures 25, 26, & 27.

European experience has been relatively short lived since rubber exposed to traffic, abrasives and snow plows is highly subject to attrition for the same reason that rubber tires and shoe heels sustain wear. Because the rubber is subjected to severe tension during the colder portion of the temperature cycle, its serviceable life is markedly reduced as a function of this prolonged stretching. These rubber cushions must be carefully caulked with high solids adhesives along the underside of their periphery and the short lengths in which they are fabricated (normally 4 feet long moldings) present a challenge to workmen since careful end to end bonding must be accomplished in the field to insure leakproofing. Since it would be difficult, if not impossible to keep the relief holes or striates free

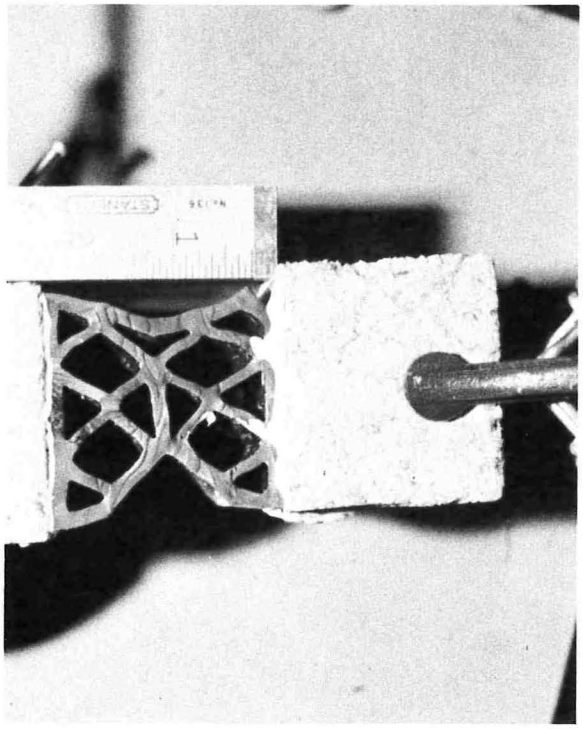

Figure 23 New adhesive system can stretch compression seal 25% beyond uncompressed width before peel occurs.

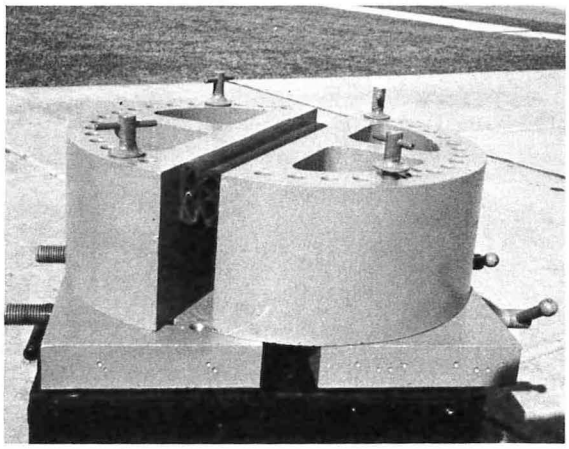

Figure 24 Variable skew testing machine programs both longitudinal and skew movements concurrently.

Figure 25 Rubber cushion joint on Italian Autostrada Bridge

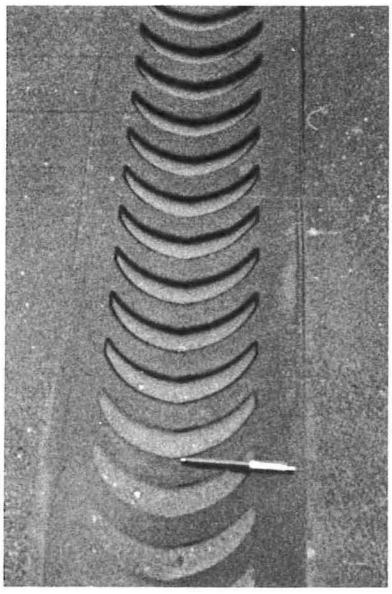

Figure 26 Relief striates tend to accumulate incompressables restricting their movement.

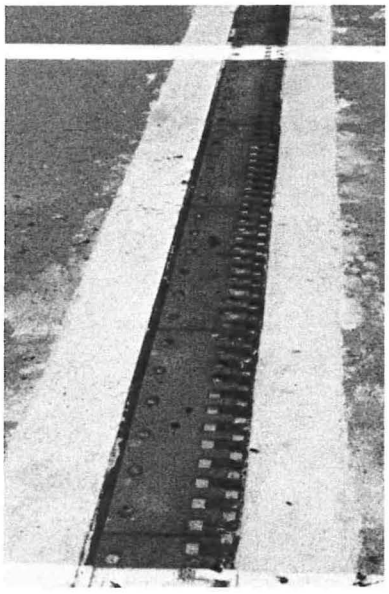

Figure 27 French combination of rubber cushion and finger joint on Paris bridge.

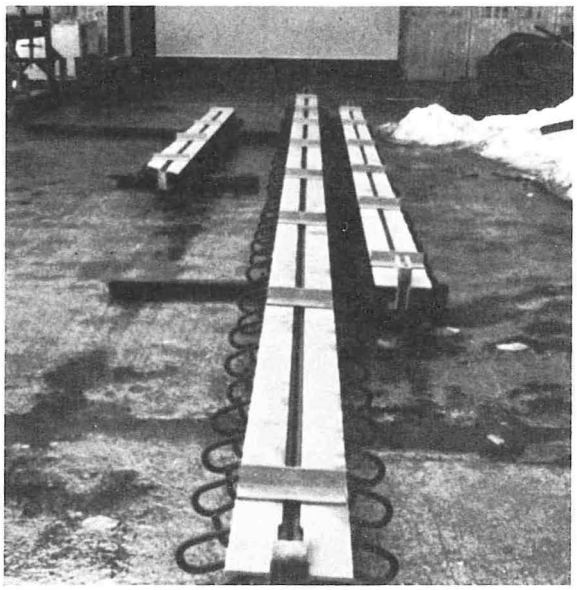

Figure 28 Precompressed compression seal in Swiss factory awaiting shipment to a bridge site.

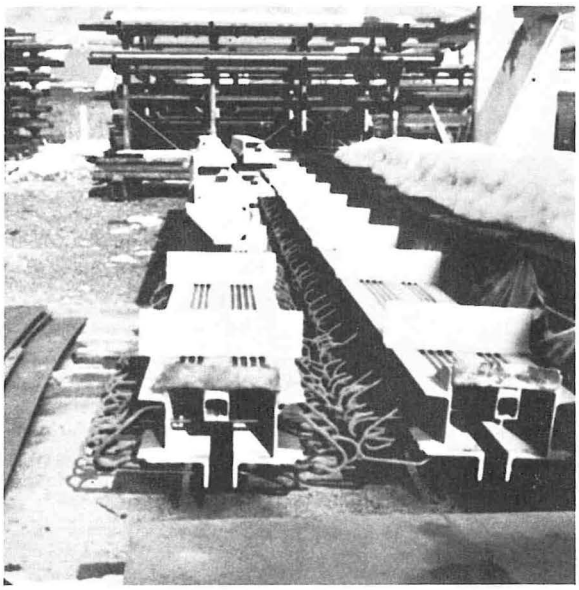

Figure 29 Factory precompressed seals for German and Austrian bridges.

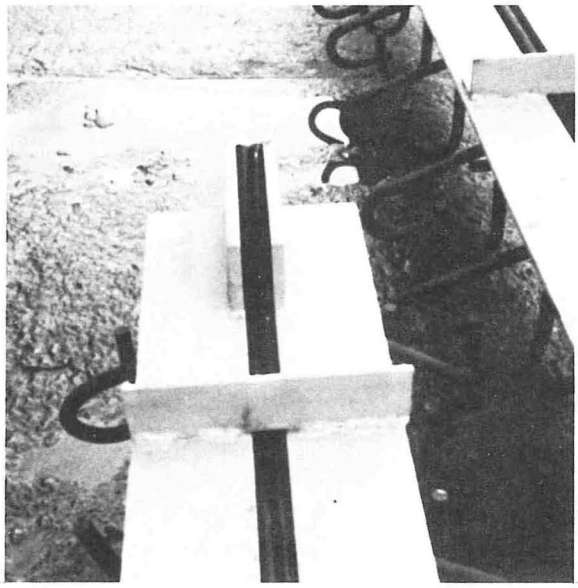

Figure 30 Curbline treatment of factory precompressed seal showing seal locked at temperature-width for an Italian Bridge.

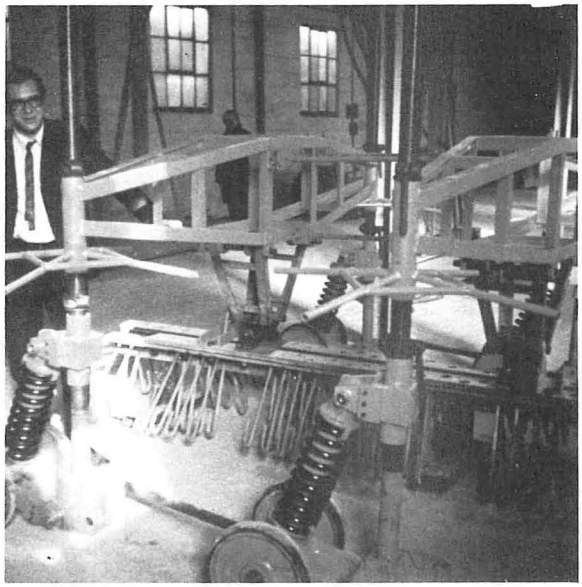

Figure 31 British factory pre-compressed seal with precision positioning rig.

EKAMPLES OF ARMORED JOINT DETAIL.

PHOTO # 2
DIV. OF RESEARCH & EVALUATION

MAY 17, 1968, Q. S. Kozlov

of intrusion of incompressibles, regular vacuum cleaning should be accomplished to keep the device in full travel particularly at the curb lines where traffic aerodynamics result in heavy accumulations of foreign material.

In Europe, they have not usually been taken through curb lines since it is not practical for rubber companies to produce specially contoured moldings to match individual bridge and curb configurations, however this is the critical area of a bridge insofar as the sealing problem is concerned.

With respect to conditions where time dependent changes in joint widths would be a design problem (creep, shrink, progressively opening or progressively closing joints), rubber cushions would not be recommended.

Some of these rubber cushion devices have incorporated steel support plates molded internally into the cushion to add structural support under traffic loading. Since by far the great majority of bridge joints are on some angle of skew, serious stresses could develop. The problem is magnified with each increased angle of skew and as spans become longer, these racking skew movements become intensified potentially resulting in structural damage to the bridge, destruction of the rubber cushion, or both.

PRECOMPRESSED SEALS IN ARMOR PLATED JOINTS

The desire for perfection in joint sealing on the part of European engineer-contractor firms who must guarantee performance for long periods of time has led to the practice in Europe of precompressing seals in armor plated joints in factories, and then taking them to the bridge site to be integrally cast into the decks (See Figures 28, 29, & 30). A British firm has developed special positioning rigging which permits precision vertical adjustments for maximum ridability (See Figure 31).

Ideal conditions for leakproofing, bonding of seals in place, neatness, workmanlike and precision adjustment to temperature-width can be assured under these circumstances. Obviously, to achieve a really 100% leakproof joint, this practice would offer a most desirable set of conditions.

Factory trained crews are beginning to replace old deteriorated bridge joints on the Italian Austrada System on a fairly large scale utilizing this technique.

A recent British innovation to North American compression seal configurations is the addition of "ears" (See Figure 32) in an obvious attempt for the ultimate in leakproofing. While severe racking from long slab skew movements could operate to tear off the ears, it does offer, within its limitation of movement, one more mechanism to aid in the quest for a leakproof joint.

DEVELOPMENT OF MODULAR SEALING CONCEPT

It is only within the last decade that the development of a modular concept of compression sealing utilizing multiples of monolithic compartmented extruded neoprene shapes has come to the fore. The trend to longer and longer spans, the realization that there is a definite causal relationship between costly, premature bridge distress and ineffective sealing practices plus the European practice of establishing legal responsiblity for maintenance being placed on the engineer-contractor has led to the rapid development of multi-seal or modular systems.

Tests have indicated that when joint widths exceed 2 1/2" they can be unacceptable not only for smaller wheeled vehicles, motor bikes and pedestrians, but more seriously, actual structural damage to the bridge is a distinct possibility under long term repetitive truck loadings. Human tolerance levels from bridge vibrations can be exceeded as a result of high impact excitation of bridges and this can be a function of excess joint width.

The relatively rapid, dynamic thermal response of the new thin, slender, prestressed, post tensioned bridges must be dealt with. The cost-conscious new light weight steel orthotropy which is rapidly becoming accepted internationally results in structures which can be grossly in need of a damping mechanism. This, added to the high cost of bridge maintenance and the undesirability of shutting down lanes in high traffic densities has placed an added emphasis on the development of maintenance free or limited maintenance sealing systems.

While it is technically possible to seal joints on bridges with monolithic seals in joint openings up to 6 inches, tolerable width considerations have resulted in a "sandwiching up" of smaller seals. An early attempt to minimize joint width and split 3 inches of movement into two joints having 1 1/2 inches utilizing standard

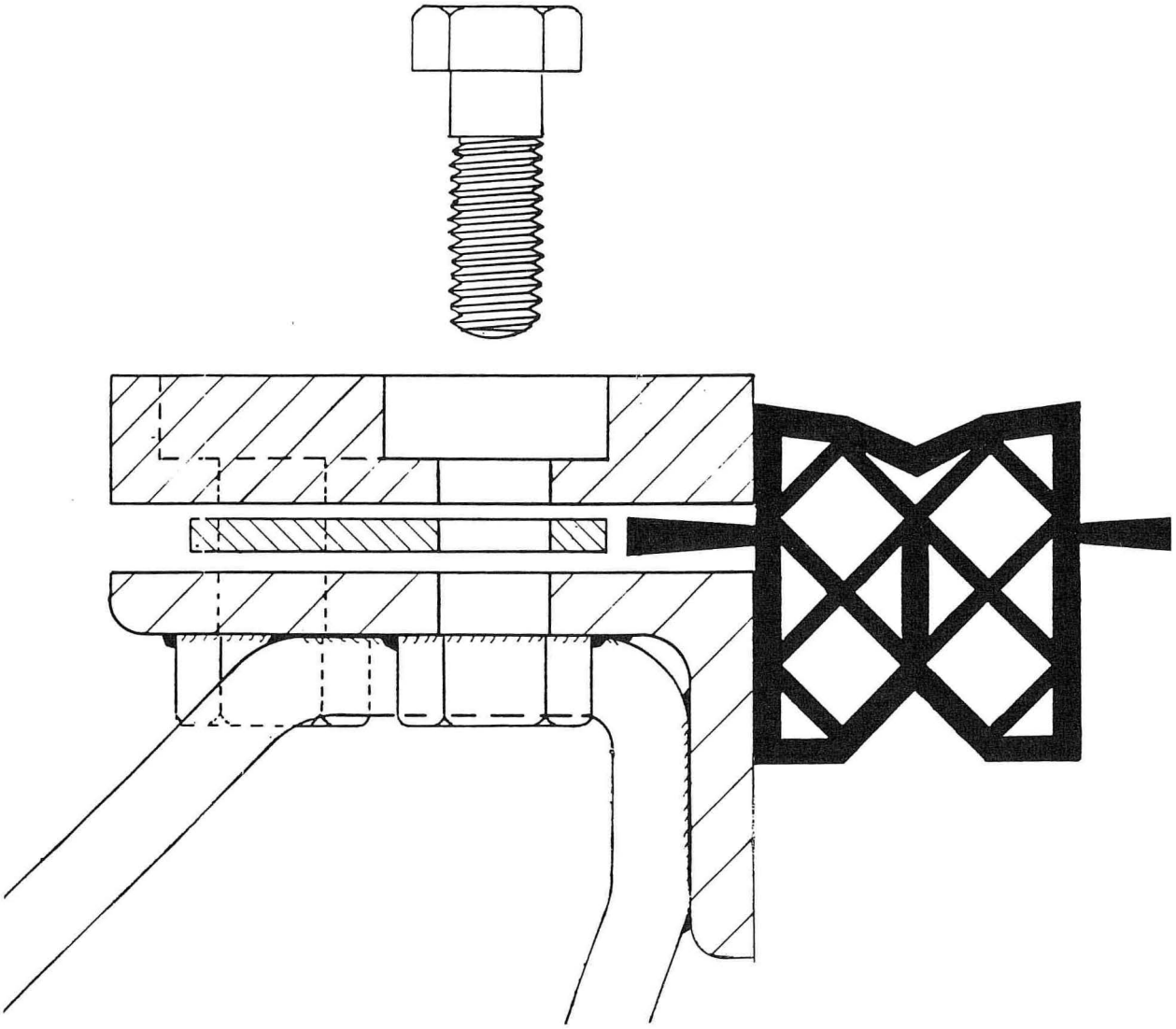

Figure 32 Compression seal with "ears" in use on British bridges.

compression seals configurations, is shown in Figure 33. For all practical purposes, there is no theoretical limit to the amount of movement that can be accommodated at a specific bridge joint utilizing the new modular concept.

Figure 34 illustrates a new North American modular sealing system covering a range of movement from 3" to 12" with each compartmented tube being responsible for 1 1/2" of movement separately.

A number of variations of modular systems have been used in Europe for the past ten years, the most popular being the RUB System. It is in wide usage throughout practically every country on the continent as well as South Africa, Asia and the Far East with a record of service approximating 500 bridges, most of them being longer spans. Figure 35 shows a RUB System incorporating a 280mm movement capability. Figure 36 illustrates a Dutch modular system while Figure 37 demonstrates a Scottish method having 2 1/4" of performance.

The North American version of a modular system is actually adapted from standard monolithic bridge seal configurations now in wide usage on short to medium length spans with the exception that the standard cross-braced shape has been redesigned to be functionally isotropic from top to bottom in an attempt to equalize sealing pressure generation along the steel separation plates.

While there is virtually unlimited movement potential in a modular system, the largest displacements being attempted today in North America are on the Halifax-Dartmouth bridge in Nova Scotia (18" of movement) and the West Lynn Bridge across the Willamette River in Oregon (12" of movement). (See Figure 38).

Performance needs in movement, angles of skew, pavement profiles and curb contours can differ widely from joint to joint, bridge to bridge, state to state and country to country. There is little similarity in the problem and there is no standard solution. So it follows that modular sealing systems are tailor made to suit the dictates of each specific bridge. However, standardization of parts has been the rule being restricted to the six basic components as shown in Figure 38.

Figure 39 typifies a modular system ready for placement in a bridge while Figure 40 illustrates a 4" system in place on a large river crossing.

An example of this design versatility is shown in Figure 41 being used on the new Bayonne River Bridge in the Province of Quebec. This system was engineered to accommodate 4 1/2 inches

Figure 33 Splitting the movement in half utilizing standard monolithic compression seals.

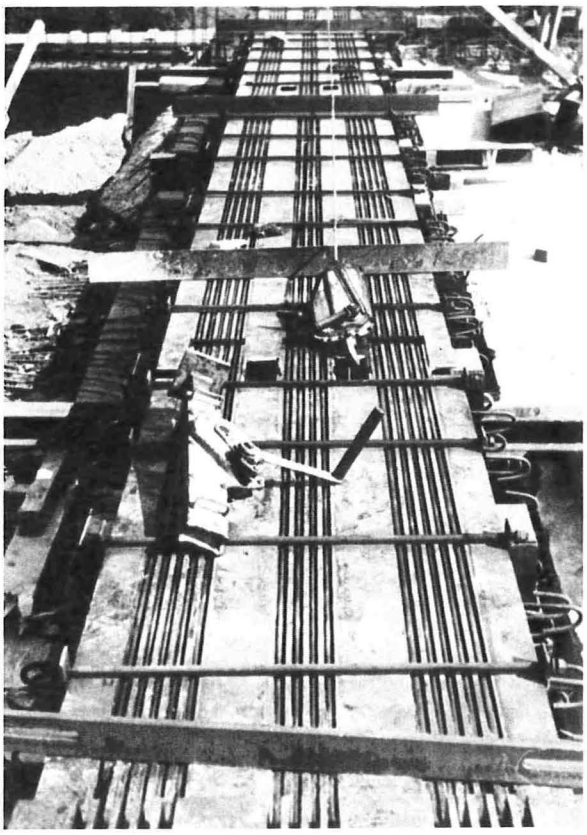

Figure 35 RUB Modular system for 280mm of movement.

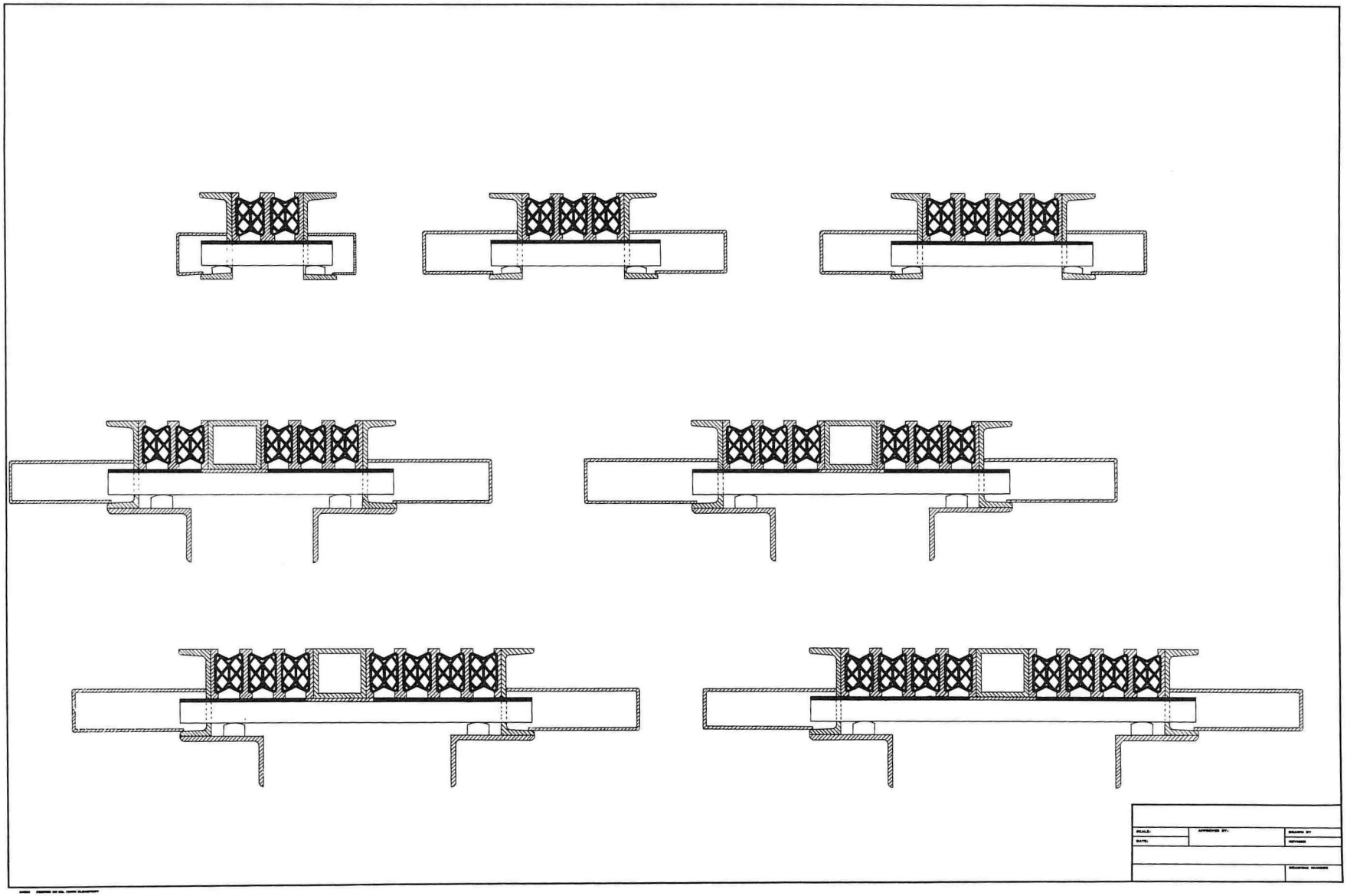

Figure 34 Typical North American modular sealing systems for 3 - 12 inches of movement, each tube individually responsible for 1 1/2 inches.

Composition of the rubber profiles

The sketches overleaf illustrate the functional shape.
The concertina-shaped top can be compressed sideways without showing a bulge; The uvala of the profile rolls inside at this movement. Through the spherical shape of the rubber profile the joint cannot be dislodged by vehicles.

Road-Joint construction

1. Backing strips
2. Backing strip holders
3. Webbing plates
4. Steel anchors
5. Mortise
6. Mounting strip
7. Adjusting anchor
8. Slot
9. Cleft
10. Plasticised rubber compound
11. Gutters

(The term "FRAME" comprises of the entire iron-construction embedded in the concrete).

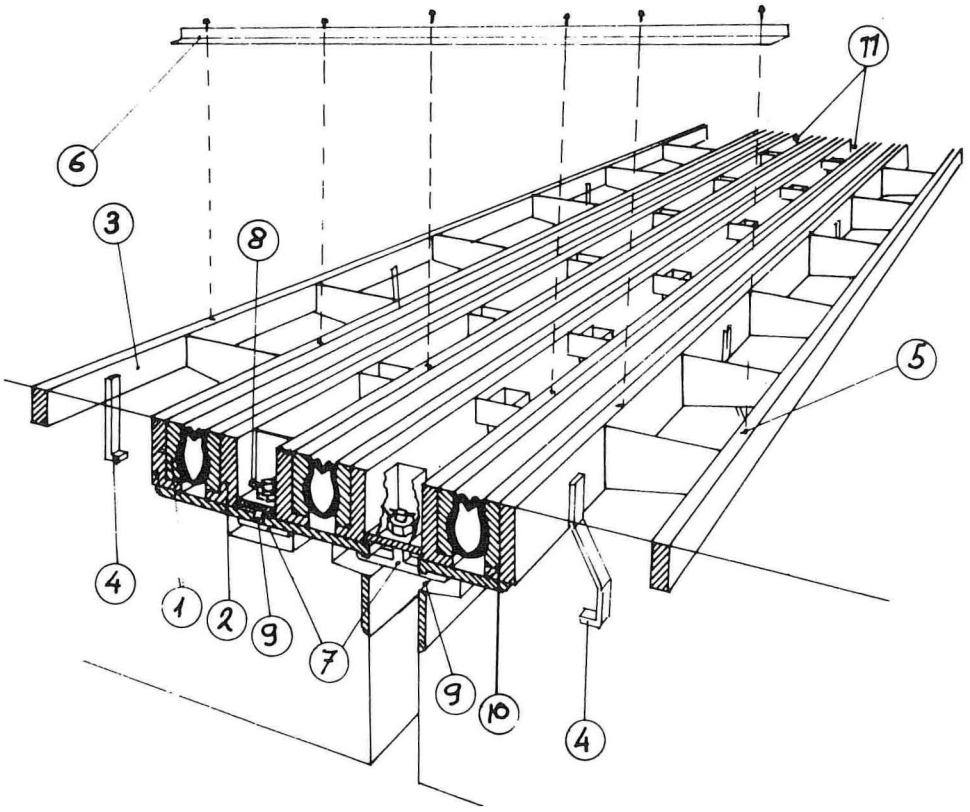

Figure 36 Example of Dutch modular system.

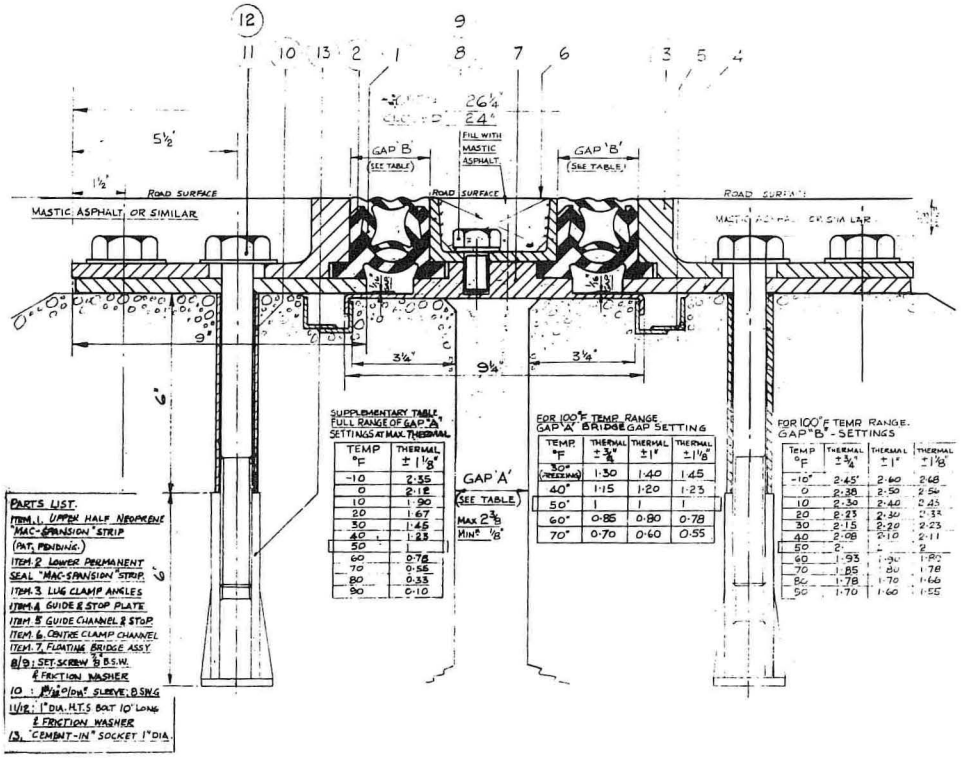
12
11 10 13 2 1 9 8 7 6 3 5 4
26¼"
24"
5½"
1½"
GAP 'B'
(SEE TABLE)
FILL WITH MASTIC ASPHALT
GAP 'B'
(SEE TABLE)
ROAD SURFACE
ROAD SURFACE
ROAD SURFACE
MASTIC ASPHALT, OR SIMILAR
9"
3¼"
9½"
3¼"
6"
6"
GAP 'A'
(SEE TABLE)
MAX 2⅜"
MIN 1/8"
PARTS LIST.
ITEM 1. UPPER HALF NEOPRENE 'MAC-SPANSION' STRIP (PAT. PENDING.)
ITEM 2. LOWER PERMANENT SEAL 'MAC-SPANSION' STRIP
ITEM 3. LUG CLAMP ANGLES
ITEM 4. GUIDE & STOP PLATE
ITEM 5. GUIDE CHANNEL & STOP
ITEM 6. CENTRE CLAMP CHANNEL
ITEM 7. FLOATING BRIDGE ASSY.
8/9: SET SCREW ⅜" B.S.W. & FRICTION WASHER
10: 1⅛" O/DIA" SLEEVE: B.S.W.G.
11/12: 1" DIA. H.T.S BOLT 10" LONG & FRICTION WASHER
13. 'CEMENT-IN' SOCKET 1" DIA.
SUPPLEMENTARY TABLE FULL RANGE OF GAP 'A' SETTINGS AT MAX. THERMAL
TEMP °C | THERMAL ± 1⅛"
-10 | 2·35
0 | 2·18
10 | 1·90
20 | 1·67
30 | 1·45
40 | 1·23
50 | 1
60 | 0·78
70 | 0·55
80 | 0·33
90 | 0·10
FOR 100°F TEMP RANGE GAP 'A' BRIDGE GAP SETTING
TEMP °F | THERMAL ±⅜" | THERMAL ±1" | THERMAL ±1⅛"
30" (FREEZING) | 1·30 | 1·40 | 1·45
40" | 1·15 | 1·20 | 1·23
50" | 1 | 1 | 1
60" | 0·85 | 0·90 | 0·78
70" | 0·70 | 0·60 | 0·55
FOR 100°F TEMP RANGE. GAP 'B' - SETTINGS
TEMP °F | THERMAL ±¾" | THERMAL ±1" | THERMAL ±1⅛"
-10" | 2·45" | 2·60 | 2·68
0 | 2·30 | 2·50 | 2·56
10 | 2·30 | 2·40 | 2·45
20 | 2·23 | 2·30 | 2·33
30 | 2·15 | 2·20 | 2·23
40 | 2·08 | 2·10 | 2·11
50 | 2" | 2" | 2
60 | 1·93 | 1·90 | 1·89
70 | 1·85 | 1·80 | 1·78
80 | 1·78 | 1·70 | 1·66
90 | 1·70 | 1·60 | 1·55

Figure 37 Example of a Scottish modular system.

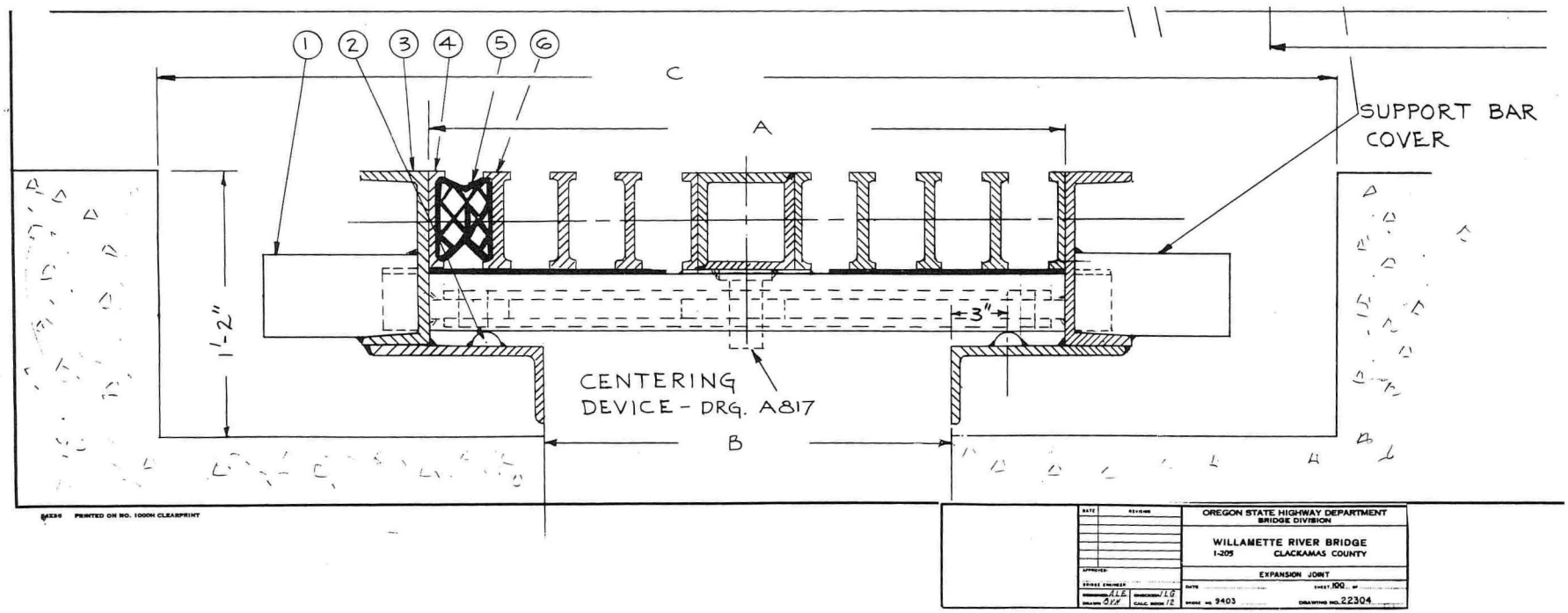

Figure 38 Modular sealing system for West Lynn Bridge over Willamette River in Oregon has 12" movement.

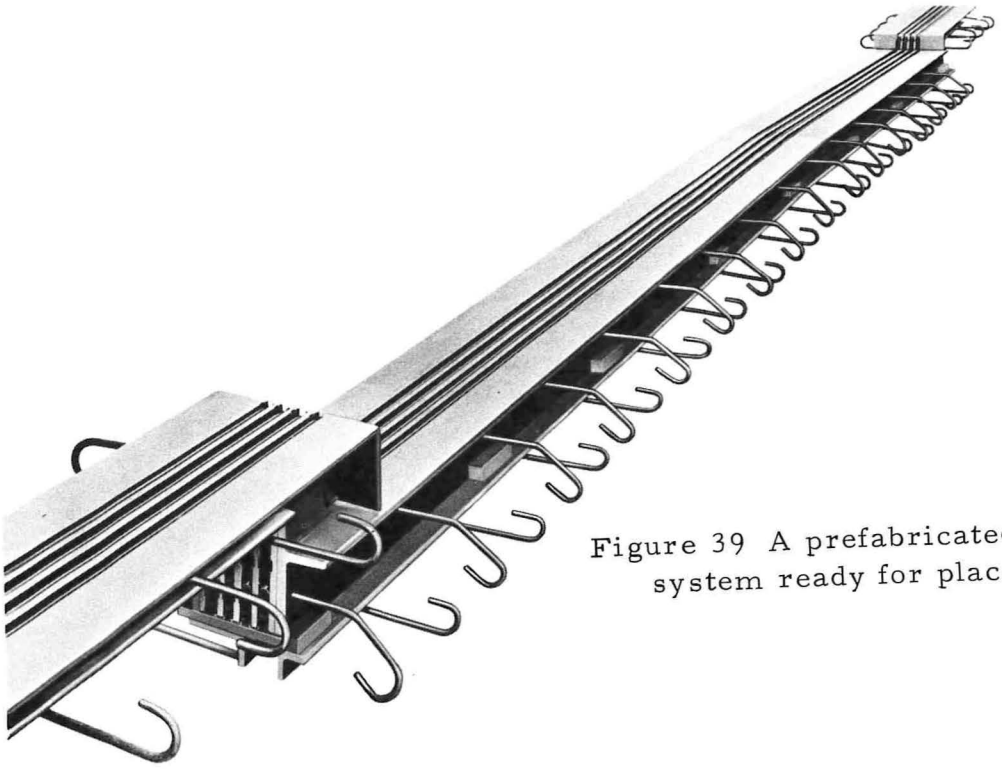

Figure 39 A prefabricated RUB modular system ready for placement.

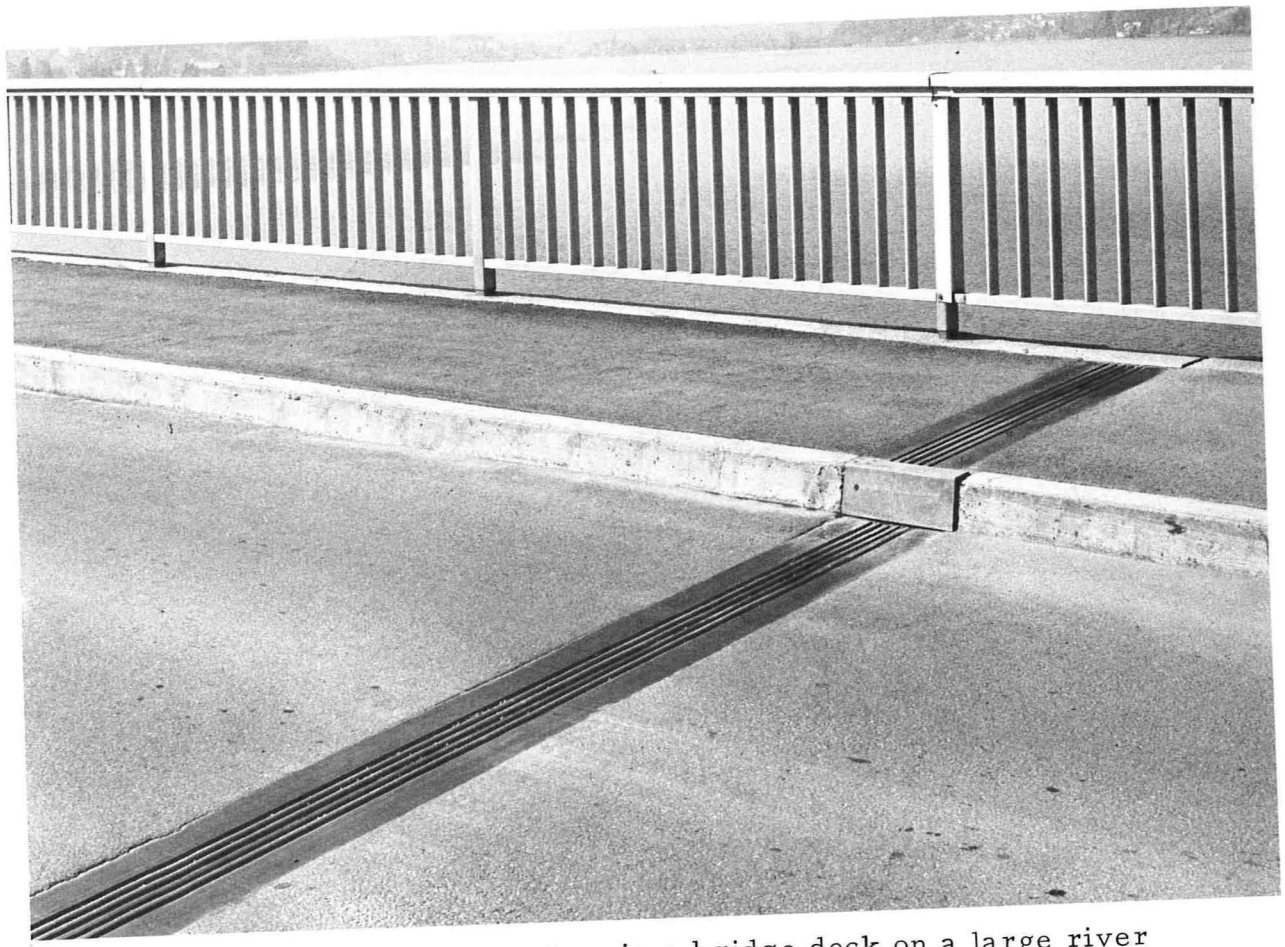

Figure 40 Modular system in a bridge deck on a large river crossing in Germany.

of longitudinal movement, the racking movement of a 28 degree skew and required that one side of the joint be cast in concrete with the other being attached to a steel deck. A further consideration was the requirement for constantly changing variations in camber throughout the transverse deck profile.

INSTALLING TECHNIQUE FOR A MODULAR SYSTEM

Since modular systems are factory prefabricated, they are preset to the anticipated temperature width and then taken to the bridge site for placement in the deck. After the concrete is placed and before excess drying shrinkage or any movement takes place, the system is activated.

Prestressment of the system is usually accomplished by jackbolts with tackwelded cross members or clamps maintaining the desired compression. Since temperatures can vary widely from the time of fabrication to the time of placement, the width setting should be adjusted just prior to installation to coincide with the correct temperature width.

Since creep and shrinkage on longer spans, particularly with post tensioning, are difficult to predict, short gaps can be left at the area of the joint to permit later installation of the sealing system. (See Figure 42). Most of the creep and shrinkage usually occurs within the first year after construction. This postponement of its installation prevents unnecessary damage to the sealing system during the construction process. It is always desirable to tie the sealing system to the main reinforcement of the bridge.

CONVERTING FOR TIME DEPENDENT CHANGES

The time dependent eccentricities of movement associated with long span bridges have been fully documented and must be accounted for in the design of a sealing system. Suffice it to say, it is not unusual to sustain permanent changes in joint width, in addition to regular thermal change, resulting in either progressively increasing or progressively decreasing joint openings. The modular sealing systems take this into account and individual seal cross sections or separator plates can be added or taken out to either relieve compressive stress or increase the movement capability as the case may be.

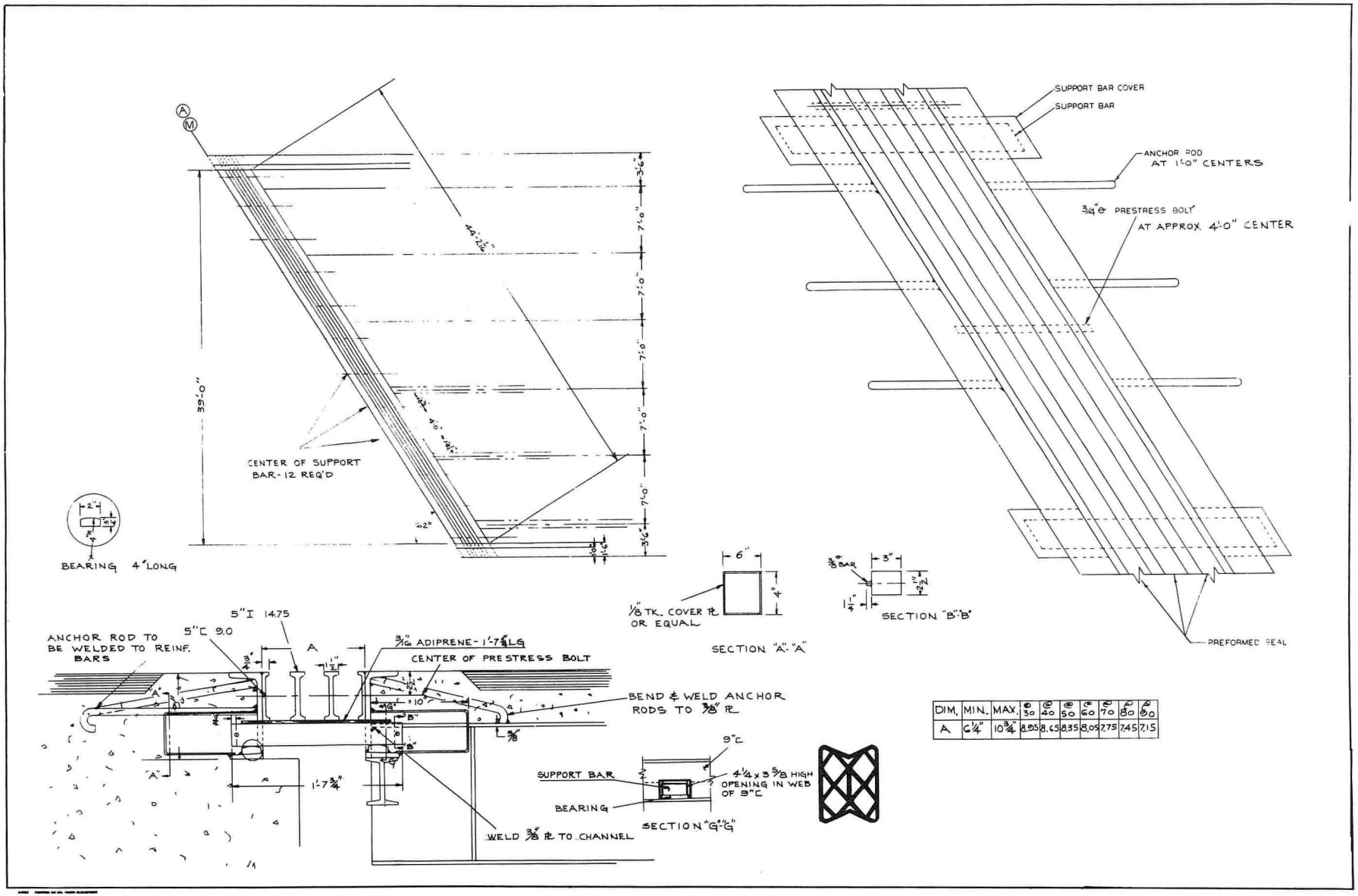
SUPPORT BAR COVER
SUPPORT BAR
ANCHOR ROD AT 1'-0" CENTERS
3/4"ø PRESTRESS BOLT AT APPROX. 4'-0" CENTER
PREFORMED SEAL
CENTER OF SUPPORT BAR - 12 REQ'D
39'-0"
BEARING 4" LONG
1/8" TK. COVER PL OR EQUAL
SECTION "A"-"A"
SECTION "B"-"B"
5"I 14.75
5"C 9.0
ANCHOR ROD TO BE WELDED TO REINF. BARS
3/16" ADIPRENE - 1'-7 3/4" LG
CENTER OF PRESTRESS BOLT
BEND & WELD ANCHOR RODS TO 3/8" PL
1'-7 3/4"
WELD 3/8" PL TO CHANNEL
SUPPORT BAR
BEARING
4 1/4 x 3 5/8 HIGH OPENING IN WEB OF 9"C
SECTION "G"-"G"
DIM. | MIN. | MAX. | @30 | @40 | @50 | @60 | @70 | @80 | @90
A | 6 1/4" | 10 3/4" | 8.95 | 8.65 | 8.35 | 8.05 | 7.75 | 7.45 | 7.15

Figure 41 Schematic of 4 1/2" movement modular system with 28 degree skew for LaRivere Bayonne Bridge in Quebec.

Figure 42 Gap in deck left for a 6" modular sealing system. System will be welded to main reinforcement of the bridge.

EXAMPLE OF ARMORED JOINT DETAIL

PHOTO #1
DIV. OF RESEARCH & EVALUATION

MAY 17, 1968 G. S. KOZLOV

BRIDGE APPROACH JOINTS

Thousands of split backwalls and blowups have occurred on our Interstate Highway System because of the historic inadequacy of the old approach expansion joints to account for time dependent pressure buildup and progressive joint closure. Since all bridges differ in their vulnerability to this phenomenon, the responsibility for the design of the approach joints should rightfully belong in the province of the bridge designer who is best able to determine their performance criteria. Modular sealing systems with their built-in provision for later adjustment appear to offer a suitable solution to this old problem. One state has reported a condition of progressively opening bridge joints on the approach, a movement phenomenon peculiar to their basic bridge and pavement design which could be inexpensively solved with a modular system.

The dynamic movement and pressures which can occur at the end joints of continuously reinforced pavement that are on bridge approaches could obviously be controlled and contained with a modular device having an adjustment versatility.

SOME INTERESTING JOINTING SOLUTIONS ON BRIDGES

Verrazano Narrows Bridge

Some 20,000 lineal feet of compression seals have been scheduled for installation on this longest bridge in the world to replace the existing sealing system which has proven ineffective. (See Figure 43). This is being made part of the second deck contract. A schematic of the solution on one type of joint is shown in Figure 44.

Golden Gate Bridge

In an attempt to stretch out the deck life of this beautiful landmark, now in its 30th year, some 11,000 lineal feet of two separate configurations of compression seals will be installed in 1968 by Golden Gate Bridge Authority maintenance forces. (See Figures 45 & 46).

Newport Bridge

The Narraganset Bay approaches to the Newport Bridge are currently under construction with some 7,200 lineal feet of large

Figure 43 Verrazano Narrows Bridge will be compression sealed.

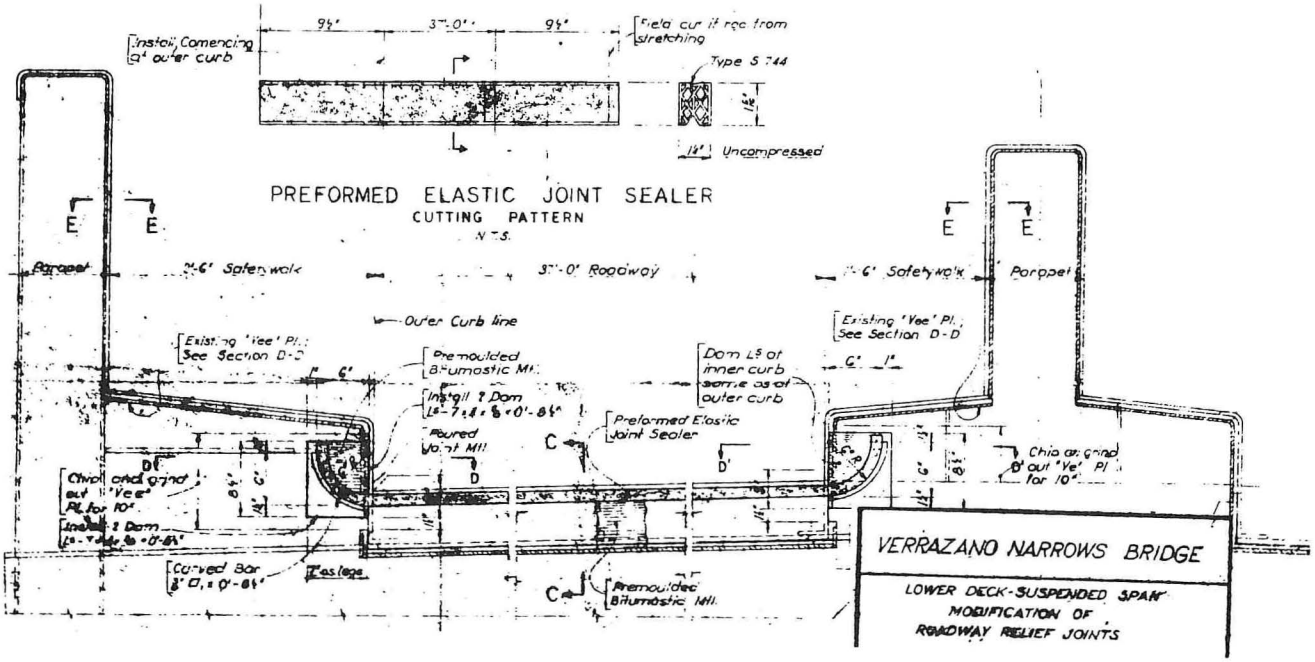

Figure 44 Plan for Deck sealing on Narrows Bridge.

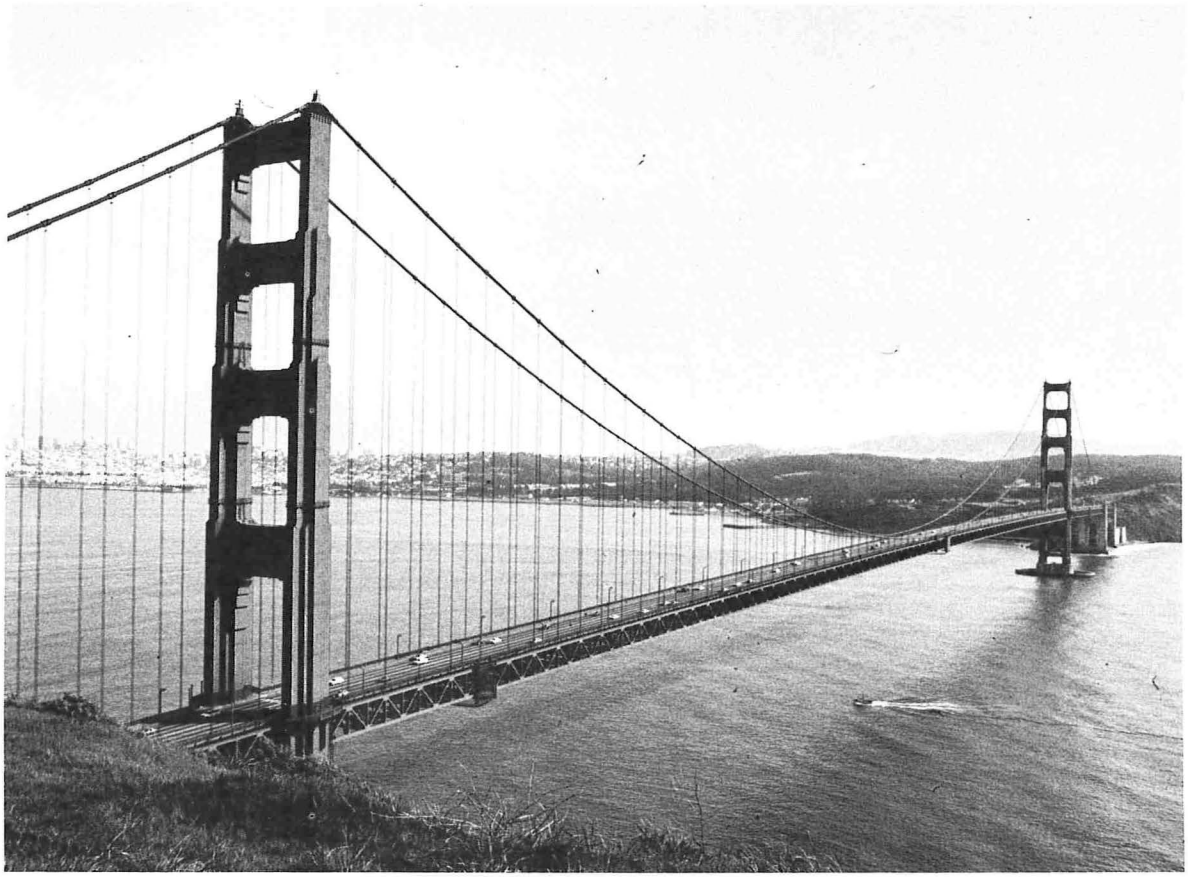

Figure 45 Golden Gate Bridge in 30th year to be compression sealed.

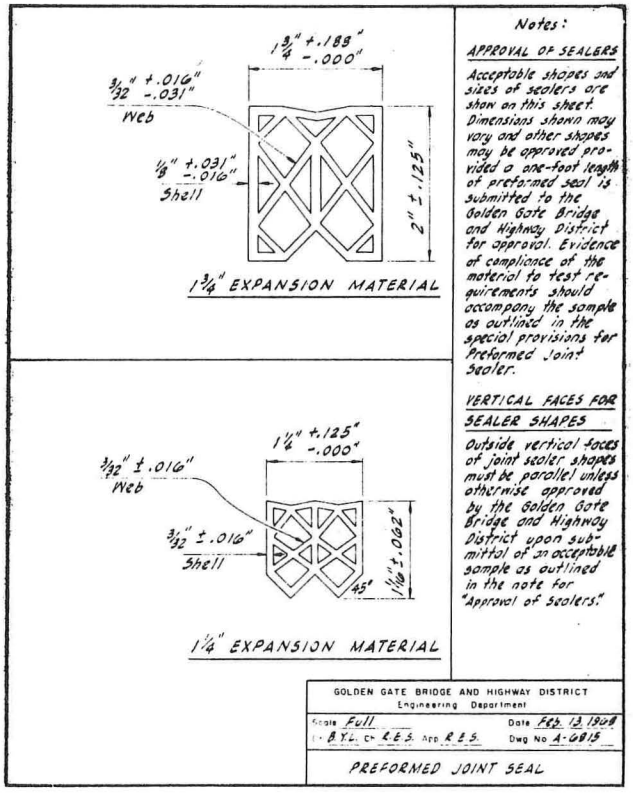
1 3/4" +.189" -.000"
3/32" +.016" -.031"
Web
1/8" +.031" -.016"
Shell
2" ± .125"
1 3/4" EXPANSION MATERIAL
1 1/4" +.125" -.000"
3/32" ± .016"
Web
3/32" ± .016"
Shell
45°
1/16" ± .062"
1 1/4" EXPANSION MATERIAL
Notes:
APPROVAL OF SEALERS
Acceptable shapes and sizes of sealers are shown on this sheet. Dimensions shown may vary and other shapes may be approved provided a one-foot length of preformed seal is submitted to the Golden Gate Bridge and Highway District for approval. Evidence of compliance of the material to test requirements should accompany the sample as outlined in the special provisions for Preformed Joint Sealer.
VERTICAL FACES FOR SEALER SHAPES
Outside vertical faces of joint sealer shapes must be parallel unless otherwise approved by the Golden Gate Bridge and Highway District upon submittal of an acceptable sample as outlined in the note for "Approval of Sealers."
GOLDEN GATE BRIDGE AND HIGHWAY DISTRICT
Engineering Department
Scale Full
Date Feb. 13, 1968
Dwg No A-6815
PREFORMED JOINT SEAL

Figure 46 Seal Configurations to be installed on Golden Gate Bridge.

compression seals presently being fabricated for installation on the 2,133 foot long Jamestown and 6,140 foot Newport sections. (See Figure 47).

Tappan Zee Bridge

20,000 lineal feet of small compression seals were specified for installation on this 3 mile long New York Thruway bridge as part of an attempt to reduce future maintenance costs.

Runnymede Bridge - England

This beautiful 173 foot long single arch span bridge has an overall length of 415 feet and carries the Staines Bypass over the Thames River near historic Runnymede. Externally finished in Portland Stone, handmade facing bricks and white concrete, a strong attempt was made to maintain its aesthetics at the joints by utilizing phosphorus bronze armor plating and compression seals. Costing 5 times that of steel, the phosphorus bronze armor, now in its tenth year, has polished to a bright golden hue and gives every indication of an exceptionally long future maintenance free life. (See Figure 48).

Burlington Skyway - Canada

The Burlington Skyway is an elevated structure in the Province of Ontario 8,400 foot in length carrying very heavy traffic on the Queen Elizabeth Way over the entrance to Hamilton Harbor. Serious corrosion of the floor beams had resulted after ten years of salt brine leakage through the joints. Some 20,000 lineal feet of compression seals were used in 1967 in an attempt to seal both the fixed joints which evidence almost instantaneous opening and closing under live loads and the breather joints which accommodate the normal thermal volume changes, drying, shrinkage, etc. (See Figures 49 - 52).

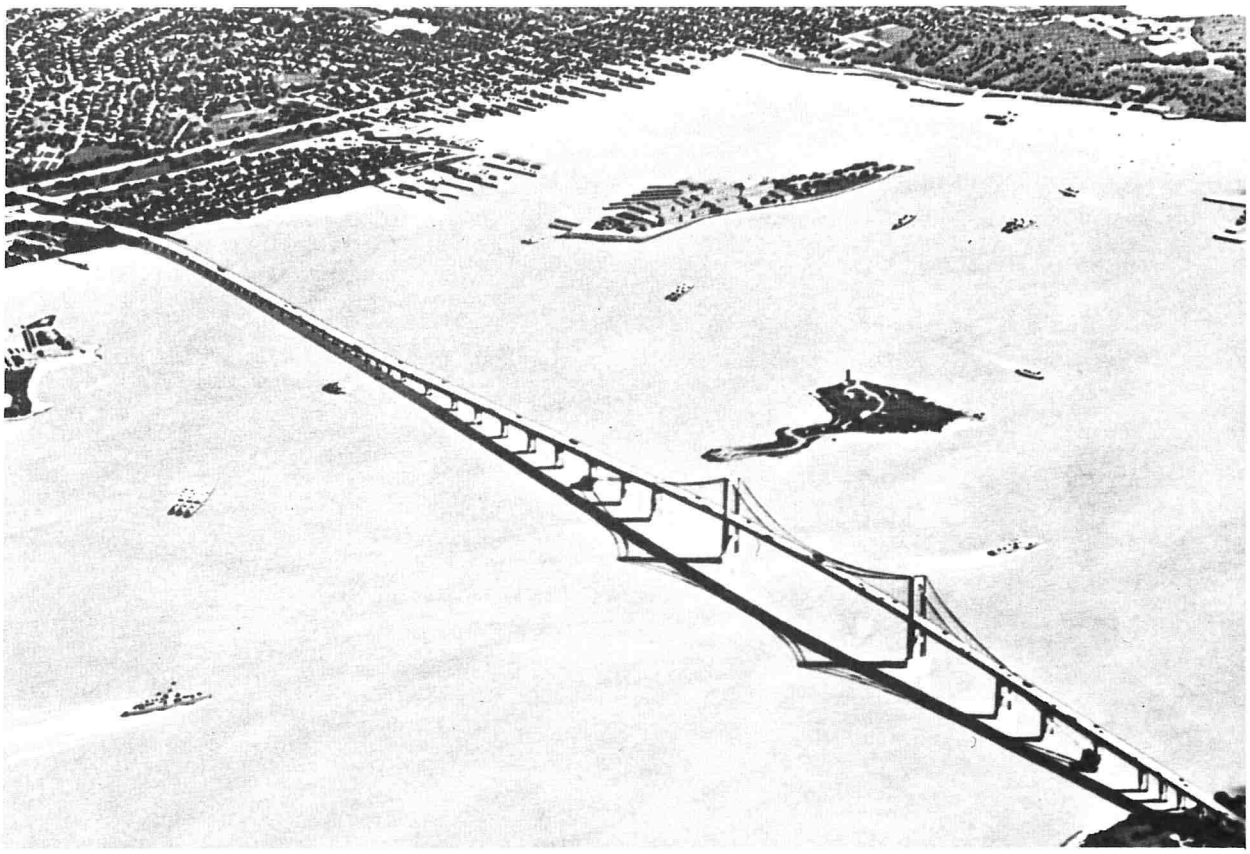

Figure 47 Newport Bridge with Narragansett Bay approaches to be compression sealed.

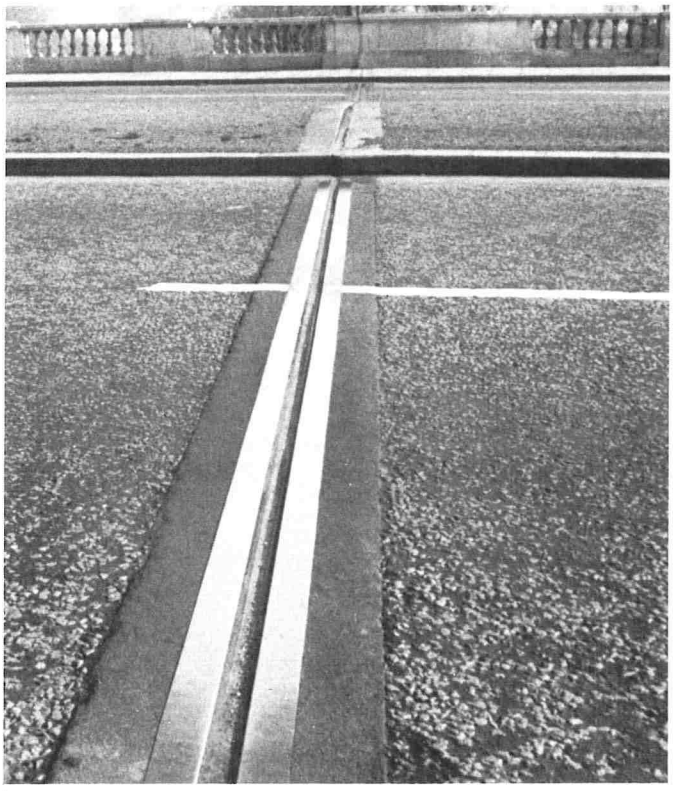

Figure 48 Phosphorus Bronze joint interfaces with compression seals on ten year old Runnymede Bridge in England.

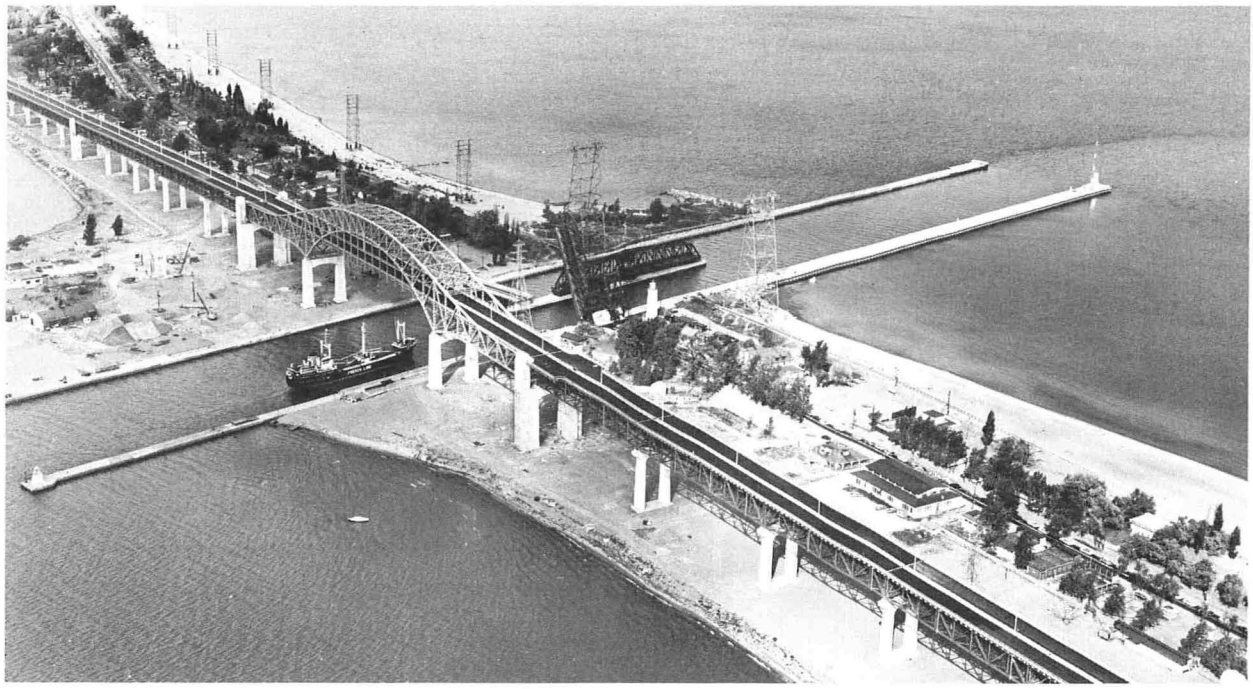

Figure 49 8,400 ft. Burlington Skyway over entrance to Hamilton, Ontario Harbor. (Photos by Dept. Highways Ontario.)

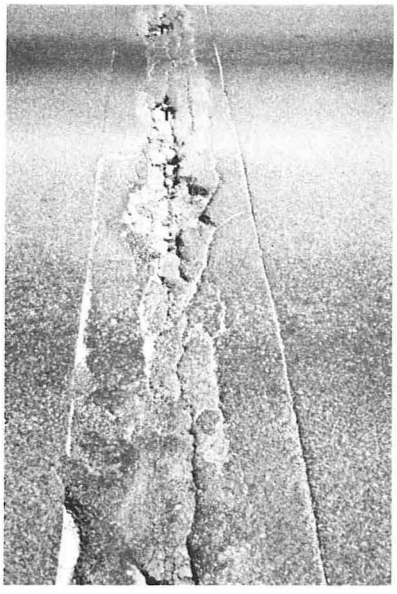

Figure 50 Burlington Skyway. Typical deteriorated joint prior to repairs.

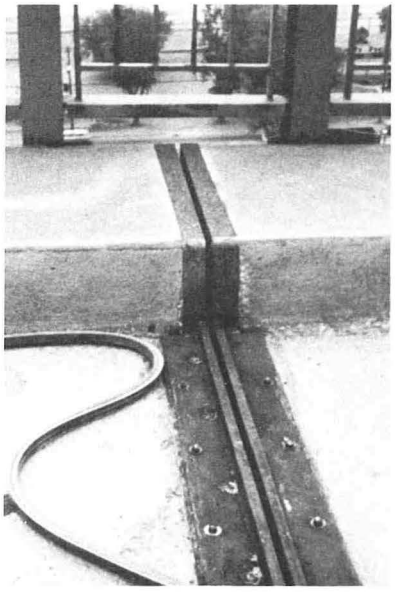

Figure 51 Burlington Skyway. Repairs to armored joints.

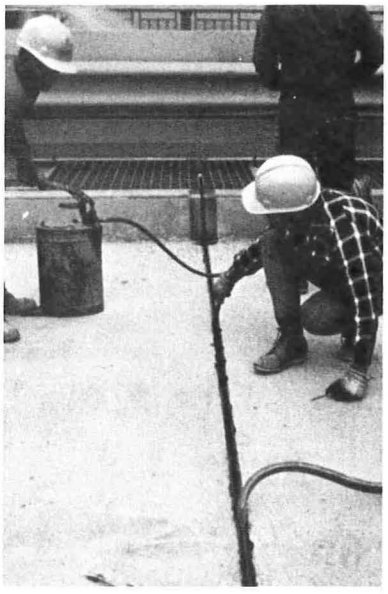

Figure 52 Burlington Skyway. Sealing sub-deck joints.

SYNOPSIS

Refinements in structural analysis; improved knowledge of material properties; wider use of prestressed concrete, composite construction, all-welded structures and battle decks; radical changes in aesthetic tastes resulting in more slender lines as well as the rapidly burgeoning cost of maintenance have operated to increase the need for improvements in jointing systems and joint sealing practices for modern bridges and structures.

The magnitude of this need is redefined and illustrated together with a performance checklist to assist bridge engineers in selecting a workable sealing system from available candidates.

The mechanics of sawing expansion joints on bridges are discussed and presented as a means of improving temperature to width control, maximum edge durability and achieving pleasing aesthetics.

Recent improvements in lubricant adhesives used with bridge compression seals have resulted in marked improvement in their performance.

Variable racking skew movements present on many bridge joints are better understood with solutions forthcoming as a result of the use of full scale testing devices.

European developments with rubber cushion devices and precompressed seals are analyzed in terms of their performance.

Some recent typical sealing solutions for long span bridges are described and illustrated.